


# 土木工程专业英语

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赠送电子课件







21 世纪全国本科院校土木建筑类创新型应用人才培养规划教材

# 土木工程专业英语

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## 内 容 简 介

本书共18章54篇文章，每篇文章都附有疑难词汇、相关练习题及参考译文和练习答案。内容涉及土木工程、交通工程、建筑材料、现代建筑、荷载及设计方法、桥梁结构、建筑施工、土力学、公路工程、环境工程、供热与通风工程、施工管理、项目管理、房地产、国际工程管理等。

本书既可作为土木工程专业本科生教材，也可供土木工程专业的教师及工程技术人员参考、阅读。


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# 目　　录

# Chapter 1

## Civil Engineering

### Section A Introduction of Civil Engineering

One of the oldest **major** is **civil engineering**. Civil engineering is that branch of engineering which aims to provide a comfortable and safe living for the people shelter. The engineering marvels of the world, starting from the pyramids to today's shell structure, are the results of the development in civil engineering. One of the primary needs of mankind is provided by civil engineers. Civil engineers design and construct buildings, railways, roads, bridges, tunnels, harbors, water and sewage systems, and other public facilities. The efficient planning of water supply and irrigation systems increases the food production in a country. Shelters, apart from just being shelters, have been constructed by civil engineers to provide a peaceful and comfortable life.

The word civil derives from the Latin for citizen. In 1782, Englishman John Smeaton used the term to differentiate his nonmilitary engineering work from that of the military engineers who predominated at the time. Since then, the term civil engineer has often been to refer to engineers who build public facilities, although the field is much broader.

The works of civil engineer include investigation (collect data before planning a project), surveying (prepare maps to locate the structure on the surface of earth), and design, construction, management, research and development, etc. The scope of civil engineering is broad, depending on the type of the project and the skills needed. Some specializations of civil engineering are listed below:

(1) Structural engineering;

(2) Geotechnical engineering;

(3) Transportation engineering;

(4) Fluid mechanics, hydraulics and **hydraulic** machines;

(5) Environmental engineering;

(6) Pipeline engineering.

Structural engineering is the most important specialization, it includes: positioning and arranging the various parts of the structure into a definite form to achieve best utilization; determining the forces that a structure must resist, its own weight, wind and **hurricane** forces, and temperature change that expand or contract construction materials, and earthquake. They also determine the combination appropriate materials: steel, **concrete**, plastic, stone, **asphalt**, brick, aluminum, or other construction materials; analyzing the behavior of parts of the structure subjected to the above forces; designing the structure such that its stability under the action of various loads is ensured; executing the work with selected construction materials and skilled workers. Most structural engineer work for apartment or public construction and factory constructions. They

design the size, style and number of reinforcing steel bars， etc.

Civil engineers who specialize in geotechnical engineering deal with the following aspects: the properties of soils and rocks as materials that support the structure; the various types of foundation for a structure; **settlements** of buildings；**stabilities** of **slopes and fills**；effects of groundwater. Because foundation is the most important part of a building, it is very complicated underground and it is difficult to **remedy** if something is wrong. These engineers analyze the properties of soils and rocks that support structures and affect structural **behaviors**. They evaluate and work to minimize the potential settlement of buildings and other structures, which stems from the pressure of their weight on the earth. These engineers also evaluate and determine how to strengthen the stability of slopes and fills and how to protect structures against earthquakes and effects of groundwater. They often perform experiment to achieve pleased result.

Transportation engineering is the science of safe and efficient movement of people and goods. It is a sub-discipline of civil engineering. The planning aspects of transportation engineering relate to urban planning, and involve technical forecasting decisions and political factors. Passenger trips are the focus of transportation engineering because they often represent the peak of demand on any transportation system. The design aspects of transportation engineering include the sizing of transportation facilities, determining the materials and thickness used in pavement, designing the geometry of the **roadway**. Operation and management involve traffic engineering, older techniques include signs, signals and markings, newer technologies involve intelligent transportation systems, including advanced traveler information systems and advanced traffic control systems.

Fluid mechanics, hydraulics and hydraulic machines, in this branch of engineering, civil engineers deal with the properties and behavior of fluids at rest or in motion. Engineers design and maintain harbors, hydroelectric dams, **waterfront** facilities, control water **runoff**，control and harness of various resources of water, they construct dams, reservoirs, and distribute channels to the **cultivable** land.

Those engaged in environmental engineering design systems to **sanitize** water and air, they provide safety drinking water for people and control pollution of water supplies, they help to build water and wastewater treatment plants, **dump** sites to eliminate **hazardous** or toxic **wastes** and prevent pollution of surrounding land.

Civil engineers in pipeline engineering build pipelines and related facilities which transport liquids, gases, or solids ranging from coal **slurries** (mixed coal and water) and semi-liquid wastes to water, oil, and various types of highly **combustible** and noncombustible gases. The engineers determine pipeline design, the economic and environmental impact of a project on regions it must traverse, the type of materials to be used-steel, concrete, plastic, or combination of various materials installation techniques, methods for testing pipeline strength, and controls for maintaining proper pressure and rate of flow of materials being transported. When hazardous materials are being carried, safety is a major consideration as well.

Though the difference of special knowledge and skills needed, structural engineers determine the member’s size, geotechnical engineers perform experiment to determine the earth capacity, transportation engineers aim at easing the transportation pressure, hydraulic engineers consider the behavior of fluids, environmental engineers study the project’s potential pollution and protecting,

pipeline engineers deal with aspects of design and installation of pipelines. These specialists always work together, computers are their necessary tool, they make extensive use of computers to handle large quantities of data and determine the best way to execute a project.

## Words and Phrases

civil engineering 土木工程
slopes and fills 边坡和路堤
waterfront ['wɔːtəfrʌnt] *n.* (都市中的)河，湖
settlement ['setlmənt] *n.* 沉降
stability [stə'biliti] *n.* 稳定性，坚固，耐久性
hydraulic [hai'drɔːlik] *adj.* 水利的，液压的
runoff ['rʌnɔːf] *n.* 流量，流泻，流放
behavior [bi'heivjə] *n.* 性能，性质
sanitize ['sænitaiz] *v.* 使清洁，除去……中的有害成分
dump [dʌmp] *n.* 垃圾堆
waste [weist] *n.* 废弃物
hazardous ['hæzədəs] *adj.* 危险的
major ['meidʒə] *n.* 专业科目
cultivable ['kʌltivəbl] *adj.* 可耕的，可培养的
remedy ['remidi] *v.* 补救，修理
roadway ['rəudwei] *n.* 路面，道路
hurricane ['hʌrikən] *n.* 飓风
asphalt ['æsfælt] *n.* 沥青
concrete ['kɔnkriːt] *n.* 混凝土
combustible [kəm'bʌstəbl] *adj.* 易燃的
slurry ['sləːri] *n.* 浆，泥浆

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

Loads to foundations are generally broken into two broad categories, gravity loads (dead and live) and ______ loads (wind and earthquake). All loads to foundations are treated as ______ loads. Live loads, wind loads, and ______ loads may actually be highly dynamic, but in practice such loads are applied as ______ static loads rather than as ______ loads.

Ⅱ. Translate the following passages from English into Chinese.

One of the primary needs of mankind is provided by civil engineers. Civil engineers design and construct buildings, railways, roads, bridges, tunnels, harbors, water and sewage systems, and other public facilities. The efficient planning of water supply and irrigation systems increases the food production in a country. Shelters, apart from just being shelters, have been constructed by civil engineers to provide a peaceful and comfortable life.

## Section B Structural Engineering

Structural engineering is a branch of civil engineering concerned with the designing and **execution** of all types of structures, such as buildings, bridges, highways, power plants, dams, transmission towers, and many other kinds of **specific** structures.

The designing phrase starts with the understand of the project, the designer must take through study of the technological and service performance requirements that must be expected from the structure, including load **intensities** and their **duration**, any **dynamic** action that might take place.

Load condition is the first factors that designers consider. The same structure in different location exhibits different design because of ground water level, soil **characteristic**. Foundation is particularly important in whole structure design. If the soil is soft, it should be strengthened. If the substructure is below the grounder water level, methods such as well points, or pumping from **sumps** should be taken to remove water.

A designer must first calculate the dead loads, live loads, earthquake and wind loads, and their combination, then selects structural system and construction materials. Finally, the designer analyzes structure and designs members. The live loads are usually provided by building codes. Steel and concrete are traditional materials, **carbon fiber** is **novel** material which has excellent strength and stiffness, but they are used only in limited application because of the high cost.

Analysis of structures aimed at determining the forces and deformations existed in members. These forces such as tension, compression, bending, shear and torsion could make structures **destroyed**. Excessive lateral sway may causes recurring damage to partions, ceilings, and other architectural details and may cause discomfort to the occupants of the building. This deformation must be kept within acceptable limits.

Structural design and structural analysis are components of structural engineering and a key component in the structural design process, they are **interlocked** subjects. The structural engineering has the objective of proportioning a structure such that it can safely carry the loads to which it may be subjected. Structural analysis provides the internal forces and structural design utilizes those forces to proportion the members or systems of members. Without structural analysis, design is impossible.

Member sizes designed are often from experience and comparison to some similar design and use of available empirical rules combined with some rough calculations. Most design are **initially** based on the strength and stability criteria, while other criteria are used to carry out checks at a later stage. To arrive at an optimum and economical design, it is usually to repeat the analysis with the revised sizes and shapes. In this stage, computer is a useful tool.

The speedy execution of the project requires the ready supply of all materials, equipment and labor when needed. The construction engineer must control whole operations. These operations include: excavation, foundation and **superstructure** construction, electrical and mechanical installation.

**Excavation** follows preparation of the site, it may be done by special **excavator**, and the soil excavated can be used for **landscaping** and **fill**. If the excavation areas are wet, **dewatering** and stabilizing of the soil become major operation; if the materials encountered are hard, blasting will be needed. There are several types of **foundation** in different structures. If defects exist, the foundation must be strengthened. In superstructure construction, it generally consists of several operations: forming, concrete production, **placement and curing**. Electrical and mechanical systems need **ancillary** space to provide a comfortable environment. All these **construction** must be **proceeded** according to drawings.

Engineers apply both technical and managerial skills, including knowledge of construction methods, planning, organizing, financing, and operating construction projects. They coordinate the activities of virtually everyone engaged in the work: the **surveyor**s, workers who lay out and construct the temporary roads and ramps, excavate for the foundation, build the forms and pour the concrete; and workers who build the steel framework. These engineers also make regular process reports to the owner of the structure.

## Words and Phrases

execution [ˌeksiˈkjuːʃən] *n.* 施工，实施，执行
specific [spiˈsifik] *adj.* 特殊的，专门的，具体的
dynamic [daiˈnæmik] *adj.* 动力的，冲击的
characteristic [ˌkæriktəˈristik] *adj.* 特有的；*n.* 特性，性能
intensity [inˈtensiti] *n.* 强度，密度
sump [sʌmp] *n.* 排水坑，集水坑
carbon fiber 碳纤维
novel [ˈnɔvəl] *adj.* 新的，异常的
excavation [ˌekskəˈveiʃən] *n.* 挖掘，开挖
landscape [ˈlændskeip] *n.* 风景，(环境)美化
fill [fil] *n.* 填土
ancillary [ænˈsiləri] *adj.* 辅助的，附属的
foundation [faunˈdeiʃən] *n.* 基础
excavator [ˈekskəveitə] *n.* 挖掘机，开凿者
proceed [prəˈsiːd] *v.* 继续进行，开始
interlock [ˌintəˈlɔk] *v.* 使联结，使组合
construction [kənˈstrʌkʃən] *n.* 建造，施工
surveyor [səːˈveiə] *n.* 测量员
dewater [diːˈwɔːtə] *n.* 排水
placement and curing 浇筑和养护
superstructure [ˈsjuːpəˌstrʌktʃə] *n.* 上部结构
duration [djuəˈreiʃən] *n.* 持续时间
destroy [disˈtrɔi] *v.* 破坏，毁坏
initially [iˈniʃəli] *adv.* 最初，开始

## Exercises

Ⅰ. Put the following into Chinese (English).

1. 流体力学
2. 给排水系统
3. 边坡和路堤稳定
4. 强度和耐久性
5. 控制水流量
6. safety factor
7. strength and stiffness
8. active recruiting
9. translate the theory into practice
10. placement and curing

Ⅱ. Fill in the blanks with the information given in the text.

In the discussion of practical mechanics the principles are outlined whereby the ______ may take a structure or mechanical component with known ______acting on it and proceed to find out the various ______those forces will have on the system. In other words, the study of mechanics might start with a beam acted upon by given forces and use established methods to predict the ______ of the beam and the force ______ within the beam due to those applied forces.

## Section C Careers in Civil Engineering

Engineering is a profession, which means that an engineer must have a specialized university education. Many government **jurisdictions** also have licensing procedures which require engineering graduates to pass an examination, similar to the **bar** examination for a lawyer, before they can actively start on their careers.

In the university, mathematics, physics, and chemistry are heavily emphasized throughout the engineering **curriculum**, particularly in the first two or three years. Mathematics is very important in all branches of engineering, so it is greatly stressed. Today, mathematics is included in **statistics**, which deals with gathering, classifying, and using numerical data, or pieces of information. An important aspect of statistical mathematics is probability, which deals with what may happen when there are different factors, or variable, that can change the results of a problem. Before the construction of a bridge is undertaken, for example, a statistical study is made of the amount of traffic the bridge will be expected to handle. In the design of the bridge, variable such as water pressure on the foundations, impact, the effects of different wind forces, and many other factors must be considered.

Because a great deal of calculations are involved in solving these problems, computer programming is now included in almost all engineering curricula. Computers, of course, can solve many problems involving calculations with greater speed and accuracy than a human being can. But computers are useless unless they are given clear and accurate instructions and information—in other words, a good program.

In spite of the heavy emphasis on technical subjects in the engineering curriculum, a current trend is to require students to take courses in the social sciences and the language arts. The relationship between engineering and society is getting closer; it is sufficient, therefore, to say again that the work performed by an engineer affects society in many different and important ways that he

or she should be aware of. An engineer also needs a sufficient command of language to be able to prepare reports that are clear and, in many cases, **persuasive**. An engineer engaged in research need to be able to write up his or her finding for scientific publications.

In the last two years, an engineering program includes subjects within the student's field of specialization. For the student who is preparing to become a civil engineer, these specialized courses may deal with such subjects as **geodetic** surveying, soil mechanics, or hydraulics.

Active **recruiting** for engineers often begins before the student's last year in the university. Many different corporations and government agencies have competed for the services of engineers in recent years. In the **science-oriented** society of today, people who have technical training are, of course, in demand. Young engineers may choose to go into environmental or sanitary engineering, for example, where environmental concerns have created many openings; or they may choose construction firms that **specialize** in highway work; or they may prefer to work with one of the government agencies that deal with water resources. Indeed, the choice is large and varied.

When the young engineer has finally started actual practice, the theoretical knowledge acquired in the university must be applied. He or she will probably be assigned at the beginning to work with a team of engineers. Thus, on-the-job training can be **acquitted** that will demonstrate his or her ability to translate theory into practice to the supervisors.

The civil engineer may work in research, design, construction supervision, maintenance, or even in sales or management. Each of these areas involves different duties, different emphases, and different uses of the engineer's knowledge and experience.

Research is one of the most important aspects of scientific and engineering practice. A researcher usually works as a member of a team with other scientists and engineers. He or she is often employed in a laboratory that is financed by government or industry. Areas of research concerned with civil engineering included soil mechanics and soil stabilization techniques, and also the development and testing of new structural materials.

Civil engineering projects are almost unique; that is, each has its own problems and design features. Therefore, careful study is given to each project even before design work begins. The study includes a survey both of **topographical** and subsoil feature of the proposed site. It also includes a consideration of possible alternatives, such as a **concrete** gravity dam or an earth- fill embankment dam. The economic factors involved in each of the possible alternatives must also be weighed. Today, a study usually includes a consideration of the environmental impact of the project. Many engineers, usually working as a team that includes surveyors, specialists in soil mechanics, and experts in design and construction, are involved in making these feasibility studies.

Many civil engineers, among them the top people in the field, work in design. As we have seen, civil engineers work on many different kinds of structures, so it is normal practice for an engineer to specialize in just one kind. In designing buildings, engineers often work as consultants to architectural or construction firms. Dams, bridges, water supply systems, and other large projects ordinarily employ several engineers whose work is coordinated by a systems engineer who is in charge of the entire project. In many cases, engineers from other disciplines are involved. In a dam project, for example, electrical and mechanical engineers work on the design of **powerhouse** and its equipment. In other cases, civil engineers are assigned to work on a project in another field; in the space program, for instance, civil engineers were necessary in the design and construction of such

structures as launching pads and rocket storage facilities.

Construction is a complicated process on almost all engineering projects. It involves scheduling the work and utilizing the equipment and materials so that cost is kept as low as possible. Safety factors must also be taken into account, since construction can be very dangerous. Many civil engineers therefore specialize in the construction phrase.

Much of the work of civil engineers is carried on outdoors, often in **rugged** and difficult **terrain** or under dangerous conditions. Surveying is an outdoor occupation, for example, and dams are often built in wild river valleys or **gorges**. Bridges, tunnels, and **skyscrapers** under construction can also be dangerous places to work. In addition, the work must also process under all kinds of weather conditions. The **prospective** civil engineer should be aware of the physical demands that will be made on him or her.

## Words and Phrases

jurisdiction [ˌdʒuəris'dikʃən] *n.*权限，管辖权
bar [bɑː] *n.*法庭，律师的职业
curriculum [kə'rikjuləm] *n.*课程，学习计划
statistic [stə'tistik] *adj.*统计学的；*n.*统计表
persuasive [pə'sweisiv] *adj.*有说服力的；*n.* 动因，诱因
recruit [ri'kruːt] *v.* 补充，招收
science-orient 注重科学的
specialize ['speʃəlaiz] *v.*专门研究，使专业化
geodetic [ˌdʒiːə'detik] *n.* 大地测量学
acquit [ə'kwit] *v.* 尽职，赦免
topographical [ˌtɔpə'græfikəl] *adj.*地形学的
powerhouse *n.* 动力室，发电厂
rugged ['rʌgid] *adj.* 崎岖的，艰难的
terrain ['terein] *n.* 地域，地带
gorge [gɔːdʒ] *n.* 峡谷
skyscraper ['skaiskreipə] *n.* 摩天楼
prospective [prəs'pektiv] *adj.* 将来的，未来的



## Exercises

Ⅰ. Decide whether the following statements are true (T) or false (F).

(　) 1. Doing experiment to achieve the properties of soils and rocks is environmental engineer’s work.
(　) 2. A structural engineer must calculate loads, and then select structural system.
(　) 3. A civil engineer need not work in research and management, they should grasp knowledge learned from lessons.
(　) 4. Steel concrete and carbon fiber are traditional materials.
(　) 5. Most preliminary designs begin with the strength and stability criteria.

Ⅱ. Translate the following passages from English into Chinese.

The architect has now chosen his structural system and his materials of construction. He has accounted for load propagation through his structural system and the effects of that propagation on the material. Thus he can provide enough material. In other words, members of proper size—for all elements of his structure to ensure that the internal stresses developed are less than those permissible for the material in question.

# 参 考 译 文

## 第 1 章　土木工程概论

### Section A　土木工程

土木工程是最古老的专业之一。它是工程的一个分支，目的是为人类提供一个舒适而安全的住处。世界上的工程奇迹，从金字塔到当今的壳结构都是土木工程发展的结果。人类的主要需求之一是由土木工程师提供的。土木工程师设计并建造房屋、铁路、道路、桥梁、隧道、港口、给水和污水系统以及其他公共设备。供水及灌溉系统的合理设计会提高一个地区粮食的产量。除了仅仅作为住处之外，由土木工程师建造的住处提供了一个和平而舒适的生活。

土木一词来源于拉丁语，意为民用。在 1782 年，英国人 John Smeaton 用这个词将非军事工程与占主导地位的军事工程的工程师区别开来。从那时起，土木工程师这个词用来指建设公共设施的工程师，尽管这一领域非常广阔。

土木工程师的工作包括调查(设计项目之前搜集资料)，测量(准备图纸以确定结构在地表的位置)和设计、施工、管理、研究和开发等。土木工程的范围很广，这取决于项目的类型及所需的技术，主要的土木工程专业如下：

(1) 结构工程；

(2) 岩土工程；

(3) 运输工程；

(4) 流体力学、水利及水利机械；

(5) 环境工程；

(6) 管道工程。

结构工程是最重要的一个专业，它包括：将结构的不同部分进行定位和布置，从而形成一个确定的形式以获得最好的利用；确定结构必须抵抗的力，结构的自重，风和飓风，使施工材料产生的膨胀和收缩的温度变化，以及地震力；确定合适的材料组合，包括钢材、混凝土、塑料、石头、沥青、砖、铝及其他建筑材料；分析在承受上面这些力时结构各部分的性能；设计结构以使它在不同荷载作用下的稳定性能够得到保证；在选定建筑材料和技术工人的情况下建造工程。大多数结构工程师从事公寓建筑、公共建筑和厂房建筑工作。他们设计构件尺寸，结构形式和钢筋数量等。

从事岩土工程专业的土木工程师研究的是以下几个方面：作为支撑结构材料的土壤和岩石的性能；结构不同的基础类型；建筑物的沉降；边坡和路堤的稳定；地下水的影响。由于基础是建筑物最重要的部分，地下情况非常复杂，出现任何错误都很难补救。这些工程师要分析支撑结构和影响结构性能的土壤及岩石的性能。他们评估并采取措施使建筑物和其他结构的重量对地面的压力引起的潜在的沉降最小化。这些工程师还评估并确定如何加强边坡和

路堤的稳定性以及如何保护结构抵抗地震和地下水的影响。工程师们经常做试验以获得满意的结果。

运输工程是人和物安全而有效运动的学科，它是土木工程的一个子学科。运输工程规划方面与城市规划相关，并涉及技术上的预先决策和政治因素。在任何运输系统中，旅客的运输需求最大，因此在运输工程中旅客的运输成为焦点。运输工程的设计包括确定运输设备的大小，确定道路所使用的材料和厚度，设计路面的几何形状。运输工程的运行和管理方面包括交通工程，旧的技术手段包含交通标志、交通信号和交通标线。新的技术手段包含智能运输系统，智能运输系统包括先进的运输信息系统和先进的交通控制系统。

流体力学、水力学和水利机械，在这个工程分支中，土木工程师研究的是处于静止或运动的流体的性能。工程师们设计并维护港口、水电坝、河流设施，控制水流量，控制并治理不同的水资源，他们建造坝、水库并把水渠分布到耕地。

从事环境工程的人们设计系统来净化水和空气，他们为人们提供安全的饮用水并控制供水污染，他们帮助建造水和废水处理厂、垃圾站来消除有危险的和有毒的废物并避免周围环境的污染。

从事管道工程的土木工程师建造管道和相关设施来运输液体、气体和固体，运输的物质范围从煤浆(煤与水混合)和半液态废弃物到水、油和各种高度易燃和不易燃的气体。工程师要确定管道的设计和工程项目对管道必经地区的经济和环境的冲击，所用材料的类型(钢材、混凝土、塑料或各种材料的组合)和安装技术，管道强度的测试方法，以及控制运输材料适当的压力和流速。当运输危险材料时，安全也是一个考虑的主要因素。

尽管所需的专业知识和技能不同，结构工程师要确定构件的尺寸，岩土工程师做试验来确定土壤的承载力，水利工程师考虑流体的性能，运输工程师的目的是减轻运输压力，环境工程师研究项目潜在的环境污染及保护，管道工程师处理的是管道的设计与安装方面的问题。然而这些专家总是一起工作，计算机是他们必备的工具，他们充分利用计算机来处理大量的数据并确定最好的方法来实施项目。

Section B　结构工程

结构工程是与各种类型结构如房屋、桥梁、公路、电厂、坝、传输塔及许多其他特种结构的设计和施工有关的土木工程的一个分支。

设计阶段开始于对项目的理解，结构师必须充分研究结构所期望的技术和使用性能需求，包括荷载强度及其作用的持续时间，任何可能发生的动力作用。

荷载情况是设计师考虑的首要因素。处于相同位置的不同结构由于水位、土壤性能的不同而显示出不同的设计。在整个设计中，基础尤其重要。如果土壤较软，基础就需要加强；如果下部结构位于地下水位线以下，那么就需要采取一些方法来排水，如井点降水和集水坑抽水。

设计师必须首先计算出恒载、活载、地震荷载，风荷载及它们的组合，然后选择结构体系和建筑材料，最后设计师分析结构并设计构件。活荷载通常由建筑规范给出。钢材和混凝土是传统的材料，碳纤维是新材料，它有良好的强度和刚度，但是由于造价较高，因而应用受到限制。

结构分析的目的是确定构件中的力和变形，如拉力、压力、弯矩、剪力和扭矩。过大的侧向摆动会引起隔墙、顶棚及其他一些建筑部分的循环破坏，也会使房屋的居住者感到不舒服。这样的变形必须限制在允许的范围内。

结构设计和结构分析是结构工程的组成部分，并且是结构设计过程中的主要部分。它们

是相互关联的主题。结构工程的目标是合理设计结构，以使其安全承受施加的荷载。结构分析给出结构的内力，结构设计是将内力合理分配给构件或构件系统。没有结构分析就不可能进行结构设计。

设计构件尺寸通常是从经验以及与一些类似的设计相比较出发并使用经验原则结合一些近似的计算。大多数设计开始都是基于强度和稳定准则，其他一些准则是在后面阶段用来进行检验的。为了得到最佳最经济的设计，通常要重复分析修订后的尺寸和形状。在这个阶段，计算机是有用的工具。

项目的快速施工需要准备好所有材料、设备和劳动力。建造师必须控制整个过程。这些过程包括：开挖，基础和上部结构的施工，电力和机械安装。

开挖是在现场准备好后进行的，由专门的挖掘机来开挖，挖出的土壤可以用于周围环境的绿化和填土。如果开挖区湿，那么排水和土壤的稳定就成为主要的操作过程；如果遇到的材料硬，将需要爆破。在不同的结构中有几种基础类型，如果基础中存在缺陷，基础就需要加强。在上部结构施工中，一般包括几个过程：支模板，混凝土的生产、浇筑和养护。电力和机械系统需要附属的空间以提供舒适的环境。所有这些过程都必须根据图纸进行。

工程师们要利用技术和施工管理技能，包括施工方法、规划、组织、资金筹措以及施工项目的操作。他们协调每一个参加工作的人员的活动，包括测量员、设计与建造临时道路与斜坡、基础开挖、搭建模板和浇筑混凝土的工人以及建造钢结构的工人。另外，工程师还定期向业主汇报工程进展情况。

### Section C　土木工程职业

土木工程师必须受过专门的高等教育，许多获得批准的政府管辖部门要求工程毕业生通过一项考试，就像律师在他们从事职业之前要通过律师的职业考试一样。

在大学里，在整个工程课程中，着重强调数学、物理和化学，尤其是在前两年或前三年。在所有的工程分支中，数学尤其重要，因此要着重强调。今天，数学包括在统计学里，它研究的是收集、分类、数据和资料的运用。统计数学中重要的一方面就是改变问题结果的概率，概率研究的是当存在不同的因素或变化时会发生什么，例如建造一座桥之前，要对这座桥将要处理的交通量进行统计研究。设计桥梁时，诸如基础上的水压力、冲击，不同风荷载的影响以及许多其他因素的变化必须考虑。

由于在解决这些问题时要进行大量计算，几乎所有的工程课程计划都设有计算机编程。当然计算机可以比人更快速准确地解决许多问题。但是，除非给出清楚而准确的指令或信息，换句话说就是好的程序，否则计算机就是无用的。

尽管在工程课程计划中着重强调技术课，但是现在的趋势是要求学生上一些社会科学和语言艺术方面的课程。工程与社会之间的联系愈来愈紧密，因此，足可以说由工程师所从事的工作以不同的方式或重要的方式影响了他（她）应该关心的社会。在许多情况下，工程师也需要足够的语言运用能力才能够使所准备的报告清晰，有说服力。从事研究的工程师应该有能力把他或她的发现写出来进行科学出版。

在最后两年，工程计划包括一些学生专业领域范围内的科目。对于打算成为土木工程师的学生，这些专业涉及测量、土力学或水力学这样一些课程。

积极应聘工程师通常是在大学的最后一年前开始的。最近几年，许多不同的公司和政府机构在竞争工程师的服务工作。在注重科学的当今社会，经过技术培训的人当然是需要的。年轻的工程师可以选择从事环境工程，例如关注环境的地方有许多岗位，或者选择专门从事公路工作的施工企业或者与某个政府机构一起解决水资源问题。实际上，选择是宽泛而变化的。

当年轻的工程师最后开始实际锻炼时，必须运用大学里获得的理论知识，他或她可能开

始被安排与一支工程师队伍一起工作。这样，实际操作能够让主管人了解他或她把理论知识运用于实践的能力。

工程师可以从事研究、设计、施工监理、维护，甚至是销售或管理工作，每一个领域包含不同的职责，不同的重点以及工程师知识和经验的不同的运用。

研究是科学和工程实践最重要的方面之一，一位研究人员通常是与其他科学家或工程师一起作为团队的成员之一进行工作。他（她）经常在政府或企业资助的实验室工作，与土木工程相关的研究领域包括土力学和土壤的稳定技术以及新结构材料的研究和试验。

土木工程项目几乎是唯一的，也就是说，每一个项目有各自的问题和设计特征。因此，在设计工作开始之前就要对每个项目进行仔细研究。研究包括项目所在位置的地形和下层土性质的研究，也包括可能选择方案的研究，如选择混凝土大坝还是填土坝。在每个可能的方案中经济性因素也必须考虑。今天，研究通常还包括项目对环境的影响。做出这些可行性研究的许多工程师常常作为一支团队进行工作，这支队伍包括测量员，土力学专家，设计和施工专家。

在这个领域的顶尖人物中，许多工程师是从事设计的。正如我们所看到的，土木工程师在许多不同种类的结构方面工作，对于一名工程师来讲，专门进行一种工作是正常的实践。设计建筑物时，工程师经常作为建筑和施工公司的顾问工作。坝、桥梁、供水系统以及其他大型项目一般要雇用几名工程师，他们的工作由负责整个项目的系统工程师来协调。许多情况下，还包括其他学科的工程师。例如，在一个坝的项目中，电力和机械工程师要进行发电厂及其设备的设计工作。在其他情况下，土木工程师被安排在一个项目的另一个领域工作，例如，在设计和施工诸如发射台和火箭储藏设备这样的结构时，土木工程师是必不可少的。

在几乎所有的工程项目中，施工是一个复杂的过程。它包括安排工作、利用设备和材料，以使造价尽可能低。施工非常危险，安全因数必须要考虑，因此许多土木工程师专门从事施工。

土木工程师的许多工作是在户外进行的，经常是在崎岖的或困难的地带或危险的情况下进行。例如，测量是户外作业，坝通常建在湍急的河流或峡谷中，施工中的桥梁、隧道和摩天楼也是危险的工作场所。另外，工作还必须在各种气候条件下进行。未来的工程师应该注意自身的身体需要。



## Grammar：专业英语的特点(Ⅰ)——文体特点

### Characteristics of English for Professional Purpose Ⅰ—Style Characteristics

专业英语是建立在一定的基础英语和专业知识之上，但并非有了这两者，就能掌握好专业英语，做好专业英语的翻译工作。就英汉两种语言而言，它们既有共同点又各具特点。要想把专业英语准确、完整地表达出来，使不同的语言交流更流畅、更方便，需要了解专业英语的特点。本篇介绍专业英语的文体特点。

(1) 专业英语归属于科技英语文体，由于科技英语的主要目的是表述科学发现、科学事实，侧重科学推理，这就使得科技英语中以客观陈述为主，被动语态使用较多，尽量使用第三人称叙述，第一人称、第二人称使用较少，以避免造成主观臆断的印象。

【例 1】 While a current is flowing through a wire，the latter is being heated.

电流流过导线时，导线就发热。

【例 2】 Before any civil engineering project can be designed, a survey at site must be made.

在设计任何土木工程项目之前，必须进行现场测量。

(2) 经常使用长句，长句一般都是含有几个复杂关系的复合句，要正确理解和翻译长句，就需要进行语法分析，搞清楚句子的中心内容和各层次之间的关系，采用合适的翻译方法准确地表达原文。

【例 3】 Manufacturing processes may be classified as unit production with small quantities being made and mass production with large number of identical parts being produced.

制造方法可分为单件小批量生产和大批量生产两类：单件小批量生产是生产少量的机件，大批量生产则是生产大量相同的零件。

【例 4】 There is enough of a difference here to indicate that one must look at the foreman's job in terms of what his situation is, whom he has to motivate and what opportunities he has to do — before deciding what sort of supervisor training is best for him.

这里的差别足以证明:在决定何种管理训练对工长最有用之前，人们必须从工长所面临的情况，即他需要促动什么人和他有哪些进行促动的机会等方面先对他的工作进行一番考察。

(3) 非人称的语气和客观的态度，常使用 It…结构。

【例 5】 It is easier to make changes in design and to correct errors during construction (and at less expense) if welding is used.

若采用焊接，则在施工阶段更容易(以更少的费用)修改设计或改正错误。

(4) 大量使用非限定性动词，如不定式、动名词、现在分词和过去分词。如：

【例 6】 The total weight being less, it is possible to build much taller buildings.

由于总重量减轻，才有可能建造更高的楼房。

【例 7】 The demands for sophisticated analysis, coupled with some serious limitations on computational capability, led to a host of special techniques for solving a corresponding set of special problems.

因为对精细分析的要求，但又受到计算能力的某些严重限制，由此产生了许多特殊方法以解决相应的一组特殊问题。

(5) 较多地使用祈使语气和公式化表达方式。

【例 8】 Suppose that $P=0$ at $x=y$.

假定当 $x=y$ 时，$P=0$。

(6) 对于一个复杂的概念，为了使之表述清楚，结构紧凑，逻辑严密，往往使用省略句和条件语句。如：

【例 9】 If not well managed, the procedure for construction may be more expensive.

如果管理不善，这一施工方法还可能更昂贵。

【例 10】 The huge investment in the infrastructure will be erased quickly if proper maintenance and rehabilitation procedures are enforced and funded.

如果合理的养护和修复计划得以资助并实施，就可迅速取消用于基础建设的巨大投资。

# Chapter 2

# New Building Structure

## Section A Steel Structure

Steel structure refers to a building in which steel plays the leading role. The early development of high-rise buildings began with structural steel framing. With the development of science and technology, the types of steel structure is growing. Steel frame building and space structure are within it.

Steel frame building consists of a skeletal frame work which carries all loads to which the building is subjected. It is made up of separate elements-beams, columns, portals, trusses, plates, **bracing**, **purlins**, etc. Beams-members carrying lateral loads in bending and shear columns-members carrying axial loads in compressing and bending, portals and trusses-members carrying lateral loads, plates-members supporting wall, bracing, together with columns and trusses, resist wind loads and stabilize the building, purlins-members carrying roof sheet. These elements must be joined together so as to be in position and carry loads without bulking out of the plane. Steel frame structures are extensively used in office, flat, industry, hospital, etc.

One of the visible changes on steel structure is the remarkable trend towards greater use of space structures; this trend is growing as a result of architectural preference. This is partly due, no doubt, to reaction from beam-column systems of previous decades, but also due to the realization of the advantages of spaces structures. Structural engineers realized many years ago the fact that space structure requires less material than the conventional linear systems and that, if properly designed, prefabricated space structures can highly economical in cost.

There are various types of space structures, differing in their behavior under load and requiring different methods of analysis. Double-layer grids are typical examples of space structures and also one of the most popular forms of space frames; they are frequently used nowadays all over the world for covering large-span industrial buildings, sports halls, churches, and exhibition centers.

Present experience shows that in many countries double-layer grids structures can complete very successfully on a cost basis with more conventional systems, providing at the same time additional advantages, such as greater rigidity, simplification of erection and the possibility of covering larger spans.

Design of connection is important in steel structure design. Joints are designed to transmit axial load, shear, moment and torsion as the frame analysis and design of members. In general, a pinned joint transmits axial load and shear; a rigid joint transmits all actions. Sliding joints to transmit a reaction only are often required where provision for expansion is needed. Joints are made by rivets, bolts and welds.

Welding results in important advantages, for example, the structure is cleaner and better looking, maintenance costs are lower. But the defects which occur in welds lead to a reduction in

strength of the joint and they may also **initiate** failure due to brittle fracture of **fatigue**. The main defects consist of: **slag inclusions**, **gas pockets**, incomplete penetration, **under cutting**, residual stress and distortion.

The two types of bolts in general use in structural steelwork are **black bolts** and **high-strength fraction grip bolts**. The black bolts are **forged** from round bars with machined **threads** on bolts and nuts, they are used in holes with 2 mm clearance, they may be used in shear, tension, torsion or in combined shear, tension and torsion. The high-strength fraction grip bolts must be tightened to give the required **shank** tension, the bolts are used in holes less than 2 mm clearance and in shear, tension, bending or in combined shear, tension and bending. Joints with high-strength fraction grip bolts can give higher capacity and little deformation compared with black bolts.

Steel sections include hot rolled and formed sections, cold-rolled sections and build-up sections. The hot rolled and formed sections, such as, equal and unequal angles, channels, structural tees, circular, square and rectangular hollow sections. The cold-rolled sections, such as zed, lipped channel. Build-up column and box column are build-up sections. For **asymmetrical** sections, the **neutral axis** must be located first. For build-up sections, the properties must be calculated.

## Words and Phrases

initiate [iˈniʃieit] *v.* 产生
slag inclusion 夹渣
gas pocket 气孔
under cutting 咬边
fatigue [fəˈtiːg] *n.* 疲劳
black bolt 粗制螺栓
high-strength fraction grip bolt 摩擦型高强度螺栓
forge [fɔːdʒ] *v.* 打制，锻造
thread [θred] *n.* 螺纹
shank [ʃæŋk] *n.* 螺杆
asymmetrical [æsiˈmetrikəl] *adj.* 非对称的
neutral axis 中和轴
bracing [ˈbreisiŋ] *n.* 支撑，拉条
purlin [ˈpɜːlin] *n.* 檩条

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

The property of a material by which it can withstand extensive ______ without failure under high ______ stress is said to be its ductility. When a mild or low-carbon steel member is being tested in tension, a considerable ______ in cross section and a large amount of ______ will occur before the actual fracture occurs. A material that does not have this property is probably hard and ______ and might break if subjected to a sudden shock.

Ⅱ. Translate the following passages from English into Chinese.

A precise value for the proportional limit is difficult to obtain, particularly when the transition

of stress-strain diagram from a straight line to a curve is gradual. For this reason, other measures of stress that can be used as a practical elastic limit are required. The yield point and the yield strength for a specified offset are frequently used for this purpose.

## Section B High Rise Building

The rapid growth of world **civilization** has a significant impact on the way humans live today. The conversation of agricultural land to development uses and the increasing **urbanization** of the world's population are making the building towards high vertically. More people go from urban to city, requiring more space for offices as for **habitation**; this increased the land use pressure and the average population density. The same area can not support sufficient facilities, the building need to be built taller and taller. The main factors which lead to the development of tall building are the following:

(1) Scarcity of land and **spiraling** rise in the cost of land;

(2) Increasing population and urbanization;

(3) Architectural requirements;

(4) **Innovation** of new structural system;

(5) Development of new material and technology.

Recent years, there have been **immense** development in the field of civil engineering in our country and they kept pace with rapid advances made in technology. One of which is the design and construction of tall buildings. A tall building is defined as one in which the structural system is modified to make it sufficiently economical to resist lateral forces due to wind or earthquakes. Within the prescribe criteria for strength, drift and the comfort of occupants.

The vertical subsystems in a tall building transmit accumulated gravity load from story to story, thus requiring larger columns or wall sections to support such loading. In addition, these same vertical subsystems must transmit lateral loads, such as wind or **seismic** loads to the foundation. But more significantly, the over turning moment and the shear deflections produced by lateral forces are larger and must be carefully provided for.

Tall buildings are constructed in the following forms:

(1) **Framed structure**: Framed structures for resisting vertical and lateral loads have long been accepted as an important and standard means for designing buildings. They provide excellent opportunity for rectangular penetration of wall surfaces both within and at the outside of a building compared to shear wall structures. Framed systems are made up of beams and columns. The ability of tall building to resist the wind and other lateral forces depends on the **rigidity** of connections between the beams and columns, but the columns are made stronger when rigidly connected to resist the lateral as well as vertical forces through frame bending. They are adopted for low and medium-rise buildings up to high-rise buildings, such as office, school, and residential use.

(2) **Shear wall structure**: When Shear walls are compatible with other functional requirements, they can be economically utilized to resist lateral forces in high-rise buildings. They are more rigid, **integrity** than frame structure. The vertical and horizontal loads are resisted by the wall, but they can resist lateral load only in the plane of the walls (i.e. not in a direction perpendicular to them). Therefore, it is always necessary to provide shear walls in two perpendicular directions, or at least in sufficient orientation so that lateral force in any direction can be resist. In the past, the shear wall

structure showed good seismic behavior and smaller damage. It is usefully employed for residential building.

(3) **Frame-shear wall**: It is composed of frame and shear wall. The vertical loads are resisted by frame and shear wall; and horizontal loads are resisted mainly by the shear wall. It is extensively used in high-rise office and hotel.

(4) **Tube**: With the increase in height and story, the horizontal seismic action of tall building increase largely. Frame, shear wall and frame shear wall structures can not satisfy this need, whereas tube which has excellent wind and seismic resistance. The tube structure includes framed tube, tube in tube and bundled tube. The framed tube system consist of an interior shear wall tube resisting partially horizontal forces and an outer frame of spaced reasonably columns. A good example of this system is Jin Mao Building, Shanghai, 1999. 88 stories. Height: 421 m (1381 ft). The tube in tube structural system is adopted for office building. It combines the interior shear wall tube with an outer framed tube. The bundled tube is also named combined tube. Several tubes combined in a plan to create large tube to make building more rigid, it is adopted for **multifunctional** high-rise building. The Sears tower, Chicago, United States, completed in 1974, 442 m (1450 ft).

(5) **Towers**: Tall structures with relatively small cross-section and with a large ratio between the height and maximum width are known as towers. We often see water towers, radio and television towers, and transmission line towers. The famous Eiffel Tower, in Paris, France, 300 m high, is constructed in1889. It is the first structure to exceed 300 m in height. The addition of a telecommunications tower in the 1950s brought the overall height to 324 m.

(6) **Silos**: It is defined as large size containers which are used to store grains, cement, coal, etc. In general, the shapes of silos are of circular cross-section.

In order to make tall building highly efficiently, the designer need to select different structural systems according to projects. Meanwhile, they should consider various criteria, such as load, strength, stability, durability, stiffness and drift, foundation settlement, **creep**, **shrinkage** and temperature effects, fire, human comfort criteria.

## Words and Phrases

immense [i'mens] *adj.* 无限的，广大的
shear wall structure 剪力墙结构
long-time *adj.* 长期的，持久的
civilization [ˌsivilai'zeiʃən] *n.* 文明
scarcity ['skεəsiti] *n.* 缺乏，稀少
urbanization [ˌəːbənai'zeiʃən] *n.* 都市化
innovation [ˌinəu'veiʃən] *n.* 革新，变革
architectural [ˌɑːki'tektʃərəl] *adj.* 建筑的
spiral ['spaiərəl] *v.*(使)成螺旋形；*adj.* 螺旋的，盘旋上升的
habitation [ˌhæbi'teiʃən] *n.* 住所，居住
rigidity [ri'dʒiditi] *n.* 刚度，刚性
multifunctional *adj.* 多功能的，多用途的
integrity [in'tegriti] *n.* 完整性，完善

seismic [ˈsaizmik] *adj.* 地震的，地震引起的
silo [ˈsailəu] *n.* 筒仓，储仓
creep [kriːp] *n.v.* 徐变，塑性变形
shrinkage [ˈʃriŋkidʒ] *n.* 收缩，缩减

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

Prestressed concrete is basically concrete in which ______ stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from ______ loads are ______ to a desired degree. In reinforced concrete members, the ______ is commonly introduced by tensioning the steel ______.

Ⅱ. Translate the following passages from English into Chinese.

The vertical subsystems in a tall building transmit accumulated gravity load from story to story, thus requiring larger columns or wall sections to support such loading. In addition, these same vertical subsystems must transmit lateral loads, such as wind or seismic loads to the foundation. But more significantly, the over turning moment and the shear deflections produced by lateral forces are larger and must be carefully provided for.

## Section C Attributes of Structural Steels



The main material of steel structure is steel, the sort of steel is many, and performance is different. Steel applied to structure is a small part, it needs some advantages. Steel production and fabrication have undergone significant and progressive changes. Today there is a wide selection of structural steels and shapes available to designers in design and construction of modern buildings and bridges.

Structural steels have excellent properties for building and bridge construction. These properties are imparted to the steels during steel making when the steel is in a liquid state, and during processing when the steel is in a solid state. Recent advances in steel making and processing enable close control of melting, alloy additions, temperatures, and cooling rates to produce steels with outstanding properties for structural applications.

Structure steels are mainly composed of iron with carefully controlled amounts of alloying elements to improve its properties. A standard tensile test in accordance with code for testing of metals may be carried out and the stress-strain curve drawn. Some of the specified properties for various grades of the structural steel need experiment, other principal properties of steel which are the same for all steels, Young's **modulus**=$2.06\times10^5$ N/mm$^2$(1N/mm$^2$=1MPa)，**Poisson ratio**=0.3, **Coefficient** of thermal expansion=$12\times10^{-5}$/°C/unit length, etc. The attributes of structural steel are as follows:

(1) high strength and light weight;

(2) desirable **ductility**;

(3) **uniformity**;

(4) **weldability**;

(5) poor **fire resistance**;

(6) poor **corrosion resistance.**

Structural steel products are manufactured to conform to BS4360. Steel is composed of about 99 percent of iron and 1 percent is carbon, **silicon**, **manganese**, **sulphur** and **phosphorus**, etc. The limits of which are as following:

| | |
|---|---|
| carbon | 0.22% |
| silicon | 0.55% |
| manganese | 0.3%～0.8% |
| sulphur and phosphorus | 0.045% |

The strength depends on the chemical composition and the work done on the section. High strength means that it can withstand higher load per unit area, meanwhile its weight is lighter. It permits more space in the structure because the structural members are relatively slender. This property is important in the design of structures such as tall buildings, long-span bridges, and airplane **hangars**. The ductility of structural steel can be defined as the property of steel that permits it to undergo large deformation without fracture. It gives the ability to resist sudden collapse and may be the single most important property of steel. Many of the simplifying assumptions used in structural steel design can be justified because of the ductility of steel. Because of the control exercised by the steel manufactures, the properties of steel along any directions are basically the same. This uniformity can eliminate the need to overdesign a member because of uncertainly about the steel. Structural steel has desirable weldability through welding, but the fire proofing and corrosion proofing are not good, this made the structure maintained **periodically**. At high temperatures, the strength of steel is drastically reduced. With such reduction in strength, buildings may collapse or members may undergo such large **distortions** that they must be removed. Some steel oxidizes when exposed to air or water，the steel forms a protective layer that resists additional corrosion, the protective layer has an attractive red-brown color and painting is not required.



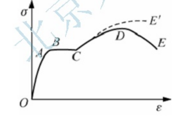



Fig.2.1 typical stress-strain curve

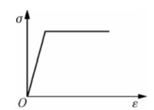



Fig.2.2 ideal elastic-plastic stress-strain curve

The typical shape of the stress-strain diagram for structural steel is shown in Fig.1. From O to A the stress and strain are directly **proportional** to one another and the diagram is linear. With an increase in loading, the strain increases more rapidly than the stress. In the region BC, the material is said to have become plastic. At the point C the material begins to **strain harden** and to offer additional resistance to increase in load until it reaches its maximum value or **ultimate** stress, at point D. Beyond this point further stretching of the bar is accompanied by a reduction in the load, and fracture of the **specimen** finally occurs at point E.

The stress-strain curve of ideal elastic-plastic in Fig. 2.2 is the basic design method used for

steel. Because steel is almost perfectly elastic, design based on elastic theory is very useful. Under load, steel follows Hooke's law up to high values of stress in both tension and compression. The **stress-strain curve** shows a **plateau** beyond the elastic limit and then increase in strength due to strain hardening. Plastic design is based on the horizontal part of the stress-strain curve. **Yield strength** is the **delimitation** between elastic stage and plastic stage, which vary with the thickness for various grades.

## Words and Phrases

ductility [dʌk'tiliti] *n.* 塑性，韧性
uniformity [ˌjuːni'fɔːmiti] *n.* 均匀性
weldability [weldə'biliti] *n.* 可焊性
fire resistance 耐火性
corrosion resistance 耐腐蚀性
plateau ['plætəu] *n.* 平台
stress-strain curve 应力-应变曲线
yield strength 屈服强度
sulphur ['sʌlfə] *n.* 硫
silicon ['silikən] *n.* 硅
manganese [ˌmæŋgə'niːz] *n.* 锰
phosphorus ['fɔsfərəs] *n.* 磷
hangar ['hæŋə] *n.* 飞机库
proportional [prə'pɔːʃənl] *adj.* 成比例的，比例上的
ultimate ['ʌltimit] *adj.* 最后的，最终的
strain harden 应变硬化
specimen ['spesimən] *n.* 试样
delimitation [diˌlimi'teiʃən] *n.* 界限，分界
periodically [ˌpiəri'ɔdikəli] *adv.* 定期地，周期地
Poisson ratio 泊松比
modulus ['mɔdjuləs] *n.* 模量
coefficient [kəui'fiʃənt] *n.* 系数
distortion [dis'tɔːʃən] *n.* 扭曲，变形

## Exercises

Ⅰ.Decide whether the following statements are true (T) or false (F).

(  ) 1. One of welding's advantages is clear and better looking.
(  ) 2. Various types of spaces structure differ in their loads and calculating methods.
(  ) 3. Structural steels with alloying elements undergo reduction in strength and large distortion.
(  ) 4. The assumption of Allowable Stress Design is that the material behaves elastically.
(  ) 5. Same factors are applied to different types of loads according to Load and Resistance Factor Design.

Ⅱ. Translate the following passages from English into Chinese.

The ductility of structural steel can be defined as the property of steel that permits it to undergo large deformation without fracture. It gives the ability to resist sudden collapse and may be the single most important property of steel. Many of the simplifying assumptions used in structural steel design can be justified because of the ductility of steel.

## 参 考 译 文

### 第 2 章　新型建筑结构

Section A　钢结构

钢结构指的是钢起主要作用的建筑物。高层结构的早期发展源于钢框架结构。随着科学和技术的进步，钢结构的形式也得到发展，钢框架和空间结构便是其中之一。

钢框架结构包含一个能够承受建筑物上所有荷载的承重骨架。它是由单独的构件组成的，如梁、柱、门架、桁架、板、支撑、檩条等。梁是承担横向荷载处于受弯和受剪的构件，柱是承担轴向荷载处于受压和弯的构件，门架和桁架是承担横向荷载的构件，板是支撑墙的构件，支撑与柱和桁架一起来抵抗风荷载并使建筑物稳定，檩条是支撑屋面板的构件。这些构件必须连接在一起才能在应有的位置承担荷载不会产生平面外屈曲。钢框架结构广泛地用于办公楼、公寓、工业建筑、医院等。

钢结构显著的变化之一就是空间结构的广泛使用，这一趋势的增长是由于建筑上的选择。无疑，这一选择部分是因为过去几十年梁柱体系得到的反应，部分是因为空间结构自身的优势。结构工程师许多年前就认识到空间结构比传统的线性体系需要的材料少，而且如果设计合理，装配的空间结构在造价上有很高的经济性。

空间结构有许多不同的类型，它们在荷载作用下的性能和所需的分析方法不同。双层网格是空间结构典型的一种形式，而且也是最普遍使用的一种空间网架，它们广泛应用于当今世界上覆盖大跨度的工业建筑、体育馆、教堂和展览中心。

目前的经验表明，在许多地区双层网格结构与更传统的体系相比在造价上能够实现得更成功，同时还具有其他优点如刚度大，安装简便，可以覆盖较大的跨度等。

在钢结构设计中，连接设计很重要。节点的设计是要传递轴向荷载、剪力、弯矩和扭矩。连接的设计与框架分析和构件设计同样重要。一般的，铰接节点传递轴力和剪力，刚节点传递所有的力，在需要采取措施限制滑移的地方经常需要滑动节点来传递作用力。节点可以采用铆钉、螺栓和焊缝连接。

焊接连接有重要的优点，例如结构整洁美观，维护费用低廉。但是在焊接过程中产生的缺陷会降低连接的强度并由于疲劳的脆性破坏而产生断裂。主要缺陷包括：夹渣、气孔、未焊透、咬边、残余应力及变形。

在钢结构中通常采用的两种螺栓是粗制螺栓和摩擦型高强度螺栓。粗制螺栓是由圆棒锻造而成，螺栓和螺母的螺纹经机械加工而成，它们与孔的间隙是 2 mm，可用于受剪力、拉力、扭矩以及剪力、拉力、扭矩的共同作用。摩擦型高强度螺栓必须拧紧以达到所需的预拉力。这种螺栓与孔的间隙小于 2 mm，可以受剪力、拉力、弯矩或者是剪力、拉力、弯矩的共同作用。摩擦型高强度螺栓比粗制螺栓的承载力强、变形小。

钢构件的截面包括热轧成型的截面、冷轧成型的截面及组合截面。热轧成型的截面如等边和不等边角钢，槽钢，T 型钢，圆形、方形和矩形钢管。冷轧成型的截面如 Z 型钢，带卷

边的槽钢。组合柱和箱型柱都是组合截面。对于非对称截面，必须要先确定中和轴的位置，对于组合截面，性能必须计算。

Section B　高层建筑

世界文明的快速发展对当今人类生活方式产生了重大影响。农业用地向开发利用的转变和世界人口都市化的增加使得建筑物向高发展。更多的人从农村走向城市，需要更多的空间用于办公和居住，这就会增加土地使用的压力和人口的平均密度。相同的区域不能够提供足够的设备，建筑物需要建得越来越高。导致高层建筑发展的主要因素如下：

(1) 缺乏土地以及地价的螺旋式上升；

(2) 人口的增加和都市化；

(3) 建筑需要；

(4) 新型结构体系的革新；

(5) 新材料和技术的发展。

最近几年，我国土木工程领域取得了巨大发展，并与技术的快速进步保持同步，其中之一是高层建筑的设计和施工。高层建筑可以解释为改进结构体系以使其足够经济来抵抗由风和地震引起的侧向力，满足规定的强度、侧移和居住的舒适性标准。

高层建筑的竖向构件从上到下逐层对累积的重力荷载进行传递，这就需要有较大尺寸的柱体或墙体来承担荷载。同时，这些构件还要将风荷载及地震荷载等侧向荷载传给基础，但是更重要的是侧向力产生的倾覆力矩和剪切变形要大得多，必须谨慎设计才能保证。

高层建筑的形式有如下几种：

(1) 框架结构：这种体系由梁和柱组成，用于抵抗竖向和水平荷载的框架结构，一直以来作为一个重要而标准的形式被采用。与剪力墙结构相比，这种结构更适合在建筑物内部或外墙上开设矩形孔洞。高层建筑抵抗风荷载和其他侧向力的能力取决于梁和柱之间连接的刚度，但当柱与梁刚性连接时，通过框架受弯来抵抗水平和竖向荷载，因此柱要做得强些。这种体系适用于低层、多层及高层建筑，如办公楼、学校和住宅。

(2) 剪力墙结构：在能够满足其他功能要求时，高层建筑中采用剪力墙可以经济地进行高层建筑的抗侧向荷载设计。剪力墙结构比框架结构的刚度和整体性更好。竖向荷载和水平荷载由墙体来抵抗，但是，剪力墙只能抵抗平行于墙平面的荷载（也就是说不能抵抗垂直于墙面的荷载）。因此总是需要在相互垂直的两个方向提供剪力墙，或至少在足够的方向提供剪力墙以抵抗任何方向的水平力。过去，剪力墙结构显示出良好的抗震性能和较小的破坏。住宅经常采用这种体系。

(3) 框架-剪力墙结构：由框架和剪力墙组成，垂直荷载由框架和剪力墙承担，水平荷载主要由剪力墙承担。这种结构广泛地用于高层办公楼和宾馆。

(4) 筒体结构：随着高度和层数的增加，高层建筑的水平地震作用极大地增加，框架、剪力墙和框架-剪力墙结构不能满足需求，而筒体具有良好的抗风和抗震性能。筒体结构包括框筒、筒中筒和束筒。框筒由内部的剪力墙和外部的框架组成，内部的剪力墙抵抗部分水平力，外部的框架柱间距合理。例如上海的金茂大厦，88 层，高 421 m。筒中筒体系适用于办公楼，它是由内部的剪力墙核心筒与外部的框筒组成。束筒也称为组合筒，几个筒在平面上组成一个大筒使建筑物刚度更大，它适用于多功能高层建筑。例如美国芝加哥的西尔斯大厦，1974 年完工，高 442 m。

(5) 塔：具有截面积小、高宽比大特点的高层建筑当属塔。我们经常看到水塔、广播电视塔以及传输线塔。法国巴黎著名的埃菲尔铁塔，高 300 m，建于 1889 年，它是第一个高度超

过 300 m 的建筑，在 20 世纪 50 年代又附加了一个无线电通讯塔，使它的总高度达到 324 m。

(6) 筒仓：可以定义为用来储存粮食、水泥、煤等的一个大尺寸容器。一般的，筒仓的形状都是圆形截面。

为了使高层建筑效能高，设计师需要根据项目选择不同的结构体系。同时，他们还要考虑不同的准则，如荷载、强度、稳定性、耐久性、刚度和侧移，基础沉降、徐变、收缩和温度影响、火及人的舒适性。

Section C 结构钢的性能

钢结构的主要材料是钢材，钢材的种类繁多，性能各不相同，可用于结构的钢材只是一小部分，它需要具备一些优点。钢的生产和加工曾经历过重大的变革。今天，设计师们在现代房屋的设计和施工中广泛选用结构钢和型钢。

结构钢具有良好的性能，可用于建造房屋和桥梁。这些性能是在钢处于液态的制造过程以及处于固态的加工过程中具备的。在钢的生产和加工过程中目前的进展能够控制熔化、合金的添加，温度以及冷却速度从而为结构的应用提供具有良好性能的钢材。

结构钢主要由碳组成并添加少量的合金元素以提高它的性能。根据规范可以进行金属的抗拉试验并可以画出应力应变图。对于不同等级结构钢的特殊性能需要进行试验，对于所有钢材的其他主要性能是相同的，杨氏模量=$2.06\times10^{5}$ MPa (现称弹性模量)，泊松比=0.3，热膨胀系数=$12\times10^{-5}$(°C/单位长度)，等等。结构钢的性能如下：

(1) 强度高重量轻；
(2) 塑性好；
(3) 各向同性；
(4) 可焊性；
(5) 耐火性差；
(6) 耐腐蚀性差。

钢制品的生产要符合 BS4360 的要求。钢是由 99%的铁和 1%的碳、硅、锰、硫、磷等组成的。这些元素的限制如下：

碳　　0.22%
硅　　0.55%
锰　　0.3%～0.8%
硫和磷　　0.045%

强度取决于化学成分和截面上的作用。强度高意味着单位面积上能够承受较大的荷载，同时重量较轻。由于构件相对较细因此可以获得较大的空间。这一性能在诸如高层结构、大跨桥梁以及飞机库这样的结构设计中很重要。结构钢的塑性可以定义为允许产生大的变形而不会破坏的性能，它是能够抵抗突然破坏的一种能力，是钢材最重要的一项性能。结构钢设计的许多简化假定之所以合理就是因为钢的塑性。由于可以控制钢的生产过程，钢的性能沿各个方向基本相同，这一均匀性能够消除由于钢的不确定性而产生的构件超设计需求。结构钢通过焊接可以获得良好的焊接性能，但是耐火性能和耐腐蚀性能不好，这就使得结构必须定期维护。在高温时，钢的强度会急剧下降。随着强度的降低，建筑物可能会发生破坏，构件可能会产生大的变形，这些破坏或变形必须消除。一些钢暴露在空气或水中会氧化，钢会形成一层保护层以阻止进一步腐蚀，保护层的颜色是引人注目的红棕色而不需要刷漆。

结构钢典型的应力应变如图 2.1 所示，从 O 点到 A 点应力和应变成比例图形为线性。随着荷载的增加，应变比应力增加得快，在 BC 段材料是塑性的，在 C 点，材料开始硬化并且

抵抗荷载的能力进一步增强，直到 D 点达到最大值或极限应力。超过这一点，伴随着荷载的减小试样进一步伸长，破坏最终在图形的 E 点产生。

图 2.2 中理想的弹塑性体应力应变曲线是用于钢设计的基本方法。由于钢几乎完全弹性，基于弹性理论的设计是有用的。在荷载的作用下，钢遵从胡克定律直到拉和压的应力值达到很高。应力应变曲线在超过弹性极限后会显示出一个平台，然后由于应变硬化强度增加。塑性设计是基于应力应变的水平部分。屈服强度是弹性阶段和塑性阶段的分界点，它随着不同等级钢材的厚度而变化。

## Grammar：专业英语的特点(Ⅱ)——词汇特点

### Characteristics of English for Professional Purpose I—Glossary Characteristics

在专业英语中，专业词汇、科技词汇多是毋庸置疑的。要想正确表达原文并能够创造性地再现原文，熟悉和领会这些词汇至关重要。

(1) 专业词汇中的一些纯专业词汇，属某一专业领域特有，其中有一部分来自古希腊和拉丁语。其特点是含义精确明晰，概念单一狭窄，如 civil 土木(来源于拉丁文)，reinforced concrete 钢筋混凝土，slope and fill 边坡和路堤。

(2) 与其他专业共用的词汇以及大量的通用科技词汇相比较，其特点是一词多义，用法灵活，应用领域广泛。翻译时，需要译者有一定的专业背景，正确把握同一个词在不同专业中的词义以及各专业共用的词义，要结合上下文给出合适的词，不可将专业词汇作为普通词汇来翻译，也不可将普通词汇硬作为专业词汇来翻译。不能随意猜测。如：transmission line 输电线路，yield strength 屈服强度，parameter 参数，modulus 模量，frequency 频率等在专业英语中基本属于通用型词汇；而“mouse”一词，在日常英语中译为“老鼠”，在计算机专业英语中译为“鼠标”。

(3) 有些词汇是通过某些词合成、派生、转化或缩写而来的。随着科学技术的发展，人类认识的逐步加深，一些新学科、新领域的新发明创造的出现，使专业英语词汇的内涵与外延逐步扩大。翻译时熟悉构词法有助于词汇的理解和记忆。常有的构词法有：

① 合成法。合成法指将两个或两个以上的词组合成一个新词，结合后形成的新词，其义多为单个词语词义的叠加，如 waterproof(防水的)，motherboard(主板)，但有的也会发生变异，翻译时要予以注意。

② 拼缀法。拼缀法(或词缀法)是指在一个词的前面或后面加上词缀构成新词的方法。科技英语中以这一方法构成的词最多。新词和含义也来源于旧词。如前缀 anti—antiparticle (反粒子)，semi—semisynthetic (半合成的)，后缀 craft—spacecraf(航天器)等。

③ 缩略法。以首字母缩略为主，即将某一词组中的几个主要词的首字母合起来组成新词。如 ASCE (American Society of Civil engineers,美国土木工程师学会)，EI (Engineering Index,工程索引)，CAD(Computer Aided Design，计算机辅助设计)。

(4) 专业英语往往包含一些理论分析、公式推导以及研究方法等，涉及的内容复杂，句子的信息量大。在翻译中，常常需要在意义上或修辞上增加或减少一些词汇，使句子的表达更容易理解。遇到一些无法直译的词汇时，应根据原文内容或上下文逻辑关系进行引申转译，有时要根据汉语的表达习惯，把原文中词义较笼统的词引申为词义较具体的词，或把词义较具体的词引申为词义较抽象的词，甚至不受原文词义的束缚，只根据词的搭配来翻译。

# Chapter 3

# Structure Materials

## Section A Civil Engineering Materials

As an engineer, one must know about the materials used in the construction site. All structures are constructed of materials known as engineering materials or building materials. It is necessary for an engineer to be conversant with the properties of such materials. Civil engineering materials can be natural and man-made. They contain **cement**, metals, timber, concrete, **bituminous** etc. Besides these traditional materials, new types of constructional materials are also investigated and developed and will be applied gradually. Now green civil engineering materials and even **eco-materials** for civil engineering are recommended based on the consideration of sustainable development. This has the benefits of reducing energy, saving resources and protecting the environment, having minimum harm to human health.

### Cement

Cement is obtained by burning at a very high temperature a mixture of **calcareous** and **argillaceous** materials. **Calcined** product is known as **clinker**. A small quantity of **gypsum** is added to the clinker and is **pulverized** into very fine powder known as cement. On **setting**, cement resembles a variety of sandstone found in Portland in England and is, therefore, called **Portland cement**.

### Types of Cement

By changing the chemical composition and by using different raw materials and additives, many types of cements can be manufactured to cater to the need of the construction industry for specific purposes. **Rapid hardening cement** is used where high strength is required instantly in initial stages. For example, repair works, early removal of **formwork**, etc. Low heat cement can be used in mass concreting works like construction of dams, etc. **Portland pozzolana cement** produces less heat of hydration and offers greater resistance to the attack of aggressive water. **Air-entraining cement** is produced by mixing a small amount of an air-entraining agent with ordinary Portland cement. By adding this, the properties of concrete can be changed and it also increases the frost resistance of hardened concrete. High strength cement is required for certain special works. To improve the strength a higher content of $C_3S$ and higher **fineness** are incorporated in ordinary Portland cement. This cement can be used for railway sleepers, **prestressed concrete**, precast concrete and air-field works.

## Concrete

Cement is mixed at or near the construction site with sand, aggregate (small stones, crushed rock, or gravel), and water to make concrete. Concrete has a high and its strength depends on the proportion in which cement, and, stones and water are mixed. It hardens with age and the process of hardening continues for a long time after the concrete has attained sufficient strength.

Normal concrete has a comparatively low tensile strength and for structural applications it is normal practice either to incorporate steel bars to resist any tensile forces (steel reinforced concrete) or to apply compressive forces to the concrete to counteract these tensile forces (pre-stressed concrete or post-stressed concrete). Concrete is used structurally in buildings, **shell structures**, bridges, sewage-treatment works, railway sleepers, roads, dams, chimneys, harbours, off-shore structures and so on. It is used also for a wide range of precast concrete products which include concrete blocks, cladding panels, and pipes.

The impact strength, as well as the tensile strength, of normal concrete is low and this can be improved by the introduction of randomly orientated fibers into the concrete. Steel, **polypropylene, asbestos glass**, carbon and even wood fibers have all been used with some success in precast products and in-situ concretes, including pipes, building panels and piles.

## Timber

Timber is one of the oldest known civil engineering materials. In addition to its usefulness as a structural material, timber has also fulfilled a role in temporary structures. Although timber is a kind of sustainable resource, the consumption speed of forests must be slowed down because of the relative slowness of tree growth.

Timber has a wide use in flooring, facing, skirting, windows, doors, stairs, **paneling** and furniture. The requirements for this purpose include ease of working and finishing, good grain pattern and appearance when clear-finished, dimensional stability in conditions of variability of temperature and humidity, both internal and external, and resistance to **infestation** and **fungal** attack etc.

Nowadays timber is also playing an important role in **falsework** carpentry, such as shuttering for in-situ or precast concrete work, supporting formwork for brick or stone arch or shell forms, or jigs for **glued-laminated** timber beam or shell forms.

## Metals

The applications of metals in civil engineering are wide and varied, ranging from their use as main structural materials to their use for fastenings and bearing materials. The properties of metals which make them unique among constructional materials are high tensile strength, the ability to be formed into plate, sections and wire, and the weld ability. Other properties of metals are electrical conductivity, high thermal conductivity and **metallic luster,** which are of importance in some circumstances. Perhaps the greatest disadvantage of the common metals, and steels in particular, is the need to protect them from corrosion by moist conditions and atmosphere.

The importance of metals as constructional materials is almost invariably related to their **load**

**bearing capacity** in either tension or compression and their ability to withstand limited deformation without fracture. It is usual to assess these properties by tensile tests in which the **modulus of elasticity**, the **yield stress**, the tensile strength and the percentage **elongation** can be determined.

Steel，basically an alloy of iron and a small amount of carbon，had been made up to that time by a laborious process that restricted it to such special uses as sword blades. After the invention of the **Bessemer process** in 1856，steel was available in large quantities at low prices. The enormous advantage of steel is its tensile strength, that is，it does not lose its strength when it is under a calculated degree of tension，a force which，as we have seen，tends to pull apart many materials. New alloys have further increased the strength of steel and eliminated some of its problems，such as fatigue，which is a tendency for it to weaken as a result of continual changes in stress.

## Bitumen/ bituminous

Engineers have made use of the excellent durability and adhesive properties of bituminous materials. Bituminous materials are for the most part in mixtures with mineral or other aggregate. The earliest known uses of bitumen and tar relate to **hydraulic** uses, for example, bitumen is used to **waterproof** a building floor. Thin coating of bitumen paints or **emulsions** applied to absorptive materials have the effect of sealing **capillaries** so that both water and water vapour are prevented from moving through the materials. Nowadays the main use of bitumen is in road surfaces, named bitumen concrete road. In order to improve the strength of bituminous materials at the high temperatures and the toughness of them at temperatures below zero, **polymer** modified bitumen, such as SBS rubber modified bitumen and APP plastics modified bitumen are widely used.

## Words and Phrases

cement [si'ment] *n.* 水泥
bituminous [bi'tju:minəs] *n.* 沥青
eco-materials *n.* 生态材料
calcareous [kæl'kɛəriəs] *adj.* 石灰质的，钙质的
argillaceous [ˌɑ:dʒi'leiʃəs] *adj.* 黏土质的，黏土的
calcined ['kælsaind] *adj.* 焙烧的，煅烧的
clinker ['kliŋkə] *n.* 水泥熟料，熟料
gypsum ['dʒipsəm] *n.* 石膏
pulverize ['pʌlvəraiz] *v.* 粉碎
set [set] *v.* 凝固，安置，调节，硬化
Portland cement 波特兰水泥，硅酸盐水泥
rapid hardening cement 快硬性水泥
formwork ['fɔ:mwə:k] *n.* 模板工程，模板
Portland pozzolana cement 火山灰质硅酸盐水泥
air-entraining cement 引气水泥
fineness ['fainnis] *n.* 细度，纯度
prestressed concrete 预应力混凝土
mould [məuld] *v.* 塑造；*n.*模具，模型

shell structure 壳体结构
polypropylene [ˌpɔli'prəupiliːn] *n.* 聚丙烯，丙纶
asbestos glass 石棉玻璃
paneling ['pænəliŋ] *n.* 嵌板，格子，镶板
infestation [infes'teiʃən] *n.* 侵染，感染，叮咬
fungal ['fʌŋgəl] *adj.* 真菌的
falsework ['fɔːlswəːk] *n.* 脚手架，临时支撑
glued-laminated *n.* 胶合叠层
metallic luster 金属光泽
load bearing capacity 承载能力
modulus of elasticity 弹性模量
yield stress 屈服应力
elongation [ˌiːlɔŋ'geiʃən] *n.* 伸长率，伸长度
Bessemer process 贝塞麦法，又称酸性底吹转炉炼钢法，由英国冶金学家 Henry Bessemer 在 1856 年首创。这是一种不需外热的、可大量生产的炼钢方法。
hydraulic [hai'drɔːlik] *adj.* 水工的，水力的，液压的
waterproof ['wɔːtəpruːf] *v.* 防水，抗水；*adj.* 防水的，耐水的，不透水的
emulsion [i'mʌlʃən] *n.* 乳液，乳化剂，乳胶
capillary [kə'piləri] *n.* 毛细，毛细管
polymer ['pɔlimə] *n.* 聚合物，高分子，高分子聚合物

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Calcined product is known ________clinker. A small ________of gypsum is added ________ the clinker and is pulverized________ very fine powder known as ________.

2. It hardens with ________ and the process of ________ continues ________a long time after the concrete has attained sufficient strength. By virtue ________ the ease with fresh concrete in its ________ may be moulded ________any shape it may be used for ________ purposes.

3. Other properties of metals are ________ conductivity, high ________conductivity and ________ luster, which are ________ importance in some circumstances.

Ⅱ. Translate the following passages from English into Chinese.

The current tendency is to develop lighter materials. Lightweight concretes are now rapidly developing throughout the world. Lightweight concrete is mainly used for their thermal insulation, for example in housing, where they give high comfort in cold climates and a low cost of cooling in hot climates. In housing, the relative weakness of lightweight concrete walls is unimportant, but it matters in roof slabs, floor slabs and beams.

Fiber obviously improves the impact resistance, fatigue and seismic properties of the concrete. Fiber can restrain from early crack and increases the flexural strength or modulus of rupture of concrete at the same time. FRC (fiber reinforced concrete) has been used in ground paving slabs for roads where flexural and impact strength are both important. FRC also provides a development orientation of cement matrix composite in the future.

# Section B Reinforced Concrete

Concrete and reinforced concrete are used as building materials in every country. In many including the Unite State and Canada, reinforced concrete is a dominant structural material in engineered construction. The universal nature of reinforced concrete construction stems from the wide availability of reinforcing bars and the constituents of concrete, gravel, sand, and cement, the relatively simple skills required in concrete construction, and the economy of reinforced concrete compared to other forms of construction. Concrete and reinforced concrete are used in bridge, buildings of all sorts, underground structures, water tanks, television towers, offshore oil exploration and production structures, dams, and even in ships.

As we know, concrete has comparatively low tensile and bending strength compared to its high compressive strength, and concrete is easy to **crack** even under a very low stress. For structural applications it is normal practice to incorporate steel bars to resist any tensile forces. Steel reinforcement is used in the concrete, can overcome the deficiencies in the tensile and bending strengths of concrete. Concrete can be **poured**, **pumped**, or even **sprayed** into all kinds of shapes. And whereas steel has great tensile strength, concrete has great strength under compression. Thus, the two substances **complement** each other.

Compared with concrete, the enormous advantage of steel is its tensile strength; that is, it does not lose its strength when it is under a calculated degree of tension, a force which, as we have seen, tends to pull apart many materials. The useful strength of ordinary **reinforcing steels** in tension as well as compression, i.e. the yield strength, is about 15 times the compressive strength of common structural concrete, and well over 100 times its tensile strength. The steel is the vital part of the structure, since concrete is deficient in tensile strength. It is possible to build a structure frame from steel without concrete, but not from concrete without steel. On the other hand, steel is a high-cost material compared with concrete. Although steel occupies only a small part of the volume of reinforced concrete (on the average about 2 percent), it is a major part of the cost. As a very rough guide, the cost of the formwork, the cost of the concrete and the cost of the steel are approximately the same, i.e. one third of the total.

It follows that the two materials are best used in combination if the concrete is made to resist the compressive stresses and the compressive force, **longitudinal** steel reinforcing bars are located close to the tension face to resist the tension force, and usually additional steel bars are so disposed that they resist the inclined tension stresses that are caused by the **shear force** in the beams. However, reinforcement is also used for resisting compressive forces primarily where it is desired to reduce the cross-sectional dimensions of compression members, as in the lower-floor columns of **multistory buildings**. Even if no such necessity exist, a minimum amount of reinforcement is placed in all compression members to safeguard them against the effects of small accidental bending moments that might crack and even fail an unreinforced member.

They also complement each other in another way: they have almost the same **rate of contraction** and **expansion**. They therefore can work together in situations where both compression and tension are factors.

Steel rods are **embedded** in concrete to make **reinforced concrete** in concrete beams or structures where tension will develop. The proper **adhesion** between the steel and the concrete is of the greatest importance, and bars should be of a sufficiently small diameter to offer an adequate area of contact with the concrete; note that the smaller the diameter of the bars, the greater their surface area for any given percentage of reinforcement. The practical limit is reached when the bars become so numerous that they obstruct the proper placing of concrete.

Concrete and steel form such a strong **bond**—the force that unites them—that no relative movements of the steel bars and the surrounding concrete occur. This bond is provided by the relatively large chemical adhesion which develops at the steel-concrete **interface**, by the natural roughness of the **mill** scale of **hot-rolled reinforcing bars**, and by the closely spaced **rib-shaped surface** deformations with which reinforcing bars are furnished in order to provide a high degree of **interlocking** of the two materials.

Still another advantage is that the steel is therefore completely surrounded by the concrete and the steel does not rust in concrete. Acid corrodes steel, whereas concrete has an **alkaline** chemical reaction, the opposite of acid. In order to minimize **corrosion** of reinforcement and consequent **spalling** of concrete under severe exposure conditions such as in bridge decks subjects to deicing chemicals, **galvanized** or **epoxy-coated** rebar may be specified.

Although the structure is made in one piece, the reinforcing bars are not. The component pieces of a **rigid** structural steel **frame** are joined together by welding of other means, and the same could be done to the bars in a concrete structure to produce a rigid frame of reinforcement. This would, however, be a considerable and unnecessary expense. We are therefore dealing with individual reinforcing bars which generally do not exceed 12 m (39 ft) in length because longer bars are difficult to transport. These bars are joined by bonding them to the concrete. The steel stress is thus transmitted to the concrete by bond or **anchorage**, and it is then transmitted to another bar by the same means. It is thus necessary to provide adequate space for the reinforcement to development the stress by transmission from the concrete.

The adoption of structural steel and reinforced concrete caused major changes in traditional construction practices. In the earlier steel of concrete frame building, the curtain walls were generally made of masonry，they had the solid look of **bearing walls**. Today, however, **curtain walls** are often made of lightweight materials such as glass, aluminum, of plastic, in carious combinations. It was no longer necessary to use thick walls of stone or brick for multistory buildings, and it became much simpler to build fire-resistant floors. Both these changes served to reduce the cost of construction. It also became possible to erect buildings with greater heights and longer spans.



## Words and Phrases

crack [kræk] *v.* 开裂；*n.* 裂纹，裂缝
pour [pɔː] *v.* 浇注，倾倒
pump [pʌmp] *v.* 抽吸，泵送
spray [sprei] *v.* 喷涂
complement [ˈkɔmplimənt] *n.* 补充，补充物

reinforcing steel = reinforcing bar 钢筋
longitudinal [lɔndʒi'tju:dinl] *adj.* 长度的，纵向的，轴向的
shear force 剪力
multistory building 多层建筑
rate of contraction 收缩率
rate of expansion 膨胀率
embed [im'bed] *v.* 放入，埋入，埋置，嵌入
reinforced concrete 配筋混凝土，钢筋混凝土
adhesion [əd'hi:ʒən] *n.* 附着力，黏合(力)
bond [bɔnd] *n.* 结合力，黏合力；*v.*握裹，黏结
interface ['intəfeis] *n.* 界面，接触面，交界面
mill [mil] *n.* 制造厂，粉碎机
hot-rolled reinforcing bar 热轧钢筋
rib-shaped surface 肋形表面
interlock [ˌintə'lɔk] *v.* 连动，联结，结合；*n.*相互关系
alkaline ['ælkəlain] *adj.* 碱性的；*n.*碱性
corrosion [kə'rəuʒən] *n.* 腐蚀，侵蚀，锈
spalling ['spɔ:liŋ] *n.* 剥落，层裂
galvanized ['gælvənaiz] *adj.* 镀锌的
epoxy-coated 环氧涂层的
rigid ['ridʒid] *adj.* 刚性的
frame [freim] *n.* 框架
anchorage ['æŋkəridʒ] *v.* 锚固；*n.*锚具
curtain wall 幕墙
bearing wall 承重墙

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. They also complement each other in another way: they have almost the same rate ________ contraction and expansion.

2. Still another advantage is that the steel is therefore completely surrounded by the ________ and the ________ does not rust in concrete. Acid corrodes steel, whereas concrete has an ________ reaction, the opposite of ________. In order to minimize ________ of reinforcement and consequent ________of concrete under severe exposure conditions such as in bridge decks subjects to ________, galvanized or epoxy-coated rebar may be specified.

Ⅱ. Translate the following passages from English into Chinese.

As the cement hydrates，large amount of ettringite are formed. When the concrete sets and develops strength, it will bond to the reinforcement and at the same time start expanding if sufficient quantities of curing water are present. Since the concrete is bonded to steel, its expansion under the restraining influence of the steel will induce tension in the latter while the concrete itself

goes into compression. At the end of moist curing, when the element is exposed to drying conditions, it will shrink like a normal Portland cement concrete.

The most common type of reinforcing steel (as distinct from prestressing steel) is in the form of round bars, sometimes called rebar, available in a large range of diameters, from 10 to 35 mm for ordinary applications and in two heavy bar sizes of 44 and 57 mm. These bars are furnished with surface deformations for the purpose of increasing resistance to slip between steel and concrete. Minimum requirements for these deformations (spacing, projection, etc.) have been developed in experimental research. Different bar producers use different patterns, all of which satisfy these requirements.

## Section C Durability of Concrete

At present, more and more destructive case of engineering due to lack of durability not insufficient strength under all kinds of serious conditions and many new questions companying with the development of concrete technology make people pay attention to the durability of concrete. The idea of which concrete should be designed according to **durability** instead of strength was accepted widely.

The durability of concrete can be defined as its resistance to **deterioration** resulting from external and internal causes. The external causes include the effects of environmental and service conditions to which concrete is subjected, such as weathering, chemical actions and wear. The internal causes are the effects of salts, particularly **chlorides** and **sulphates** in the constituent materials, interaction between the constituent materials, such as **alkali** aggregate reaction, volume changes, **absorption** and **permeability**.

In order to produce a durable concrete care should be taken to select suitable constituent materials. It is also important that the mix contains adequate quantities of materials in proportions suitable for producing a **homogeneous** and fully compacted concrete mass.

### Freeze-thawing

Deterioration of concrete by weathering is usually brought about by the **disruptive** action of alternate freezing and **thawing** of free water within the concrete and expansion and contraction of the concrete, under restraint, resulting from variations in temperature and alternate wetting and drying.

Damage to concrete from freezing and thawing arise from the expansion of pore water during freezing, in a condition of restraint, if repeated a sufficient number of times, this results in the development of hydraulic pressure capable of disrupting concrete. Road **kerbs** and slabs, dams and **reservoirs** are very susceptible to frost action.

The resistance of concrete to freezing and thawing can be improved by increasing its impermeability. This can be achieved by using a mix with the lowest possible water cement ratio **compatible** with sufficient **workability** for placing and compacting into a homogenous mass. Durability can be further improved by using air entrainment, an air content of 3 to 6 percent of the volume of concrete normally being adequate for most applications. The use of air-entrained concrete is particularly useful for roads where salts are used for **deicing**.

### Chemical attack

In general, concrete has a low resistance to chemical attack. There are several chemical agents, which react with concrete, but the most common forms of attack are those associated with **leaching**, **carbonation**, chlorides and sulphates (Fig.3.1). Chemical agents essentially react with certain compounds of the hardened **cement paste** and the resistance of concrete to chemical attack, therefore can be affected by the type of cement used. The resistance to chemical attack improves with increased impermeability.

### Wear

The main causes of wear of concrete are **cavitation** effects of fast-moving water, **abrasive** material in water, wind blasting and **attrition** and impact of traffic. Certain conditions of hydraulic flow result in the formation of cavities between the flowing water and the concrete surface. These cavities are usually filled with water vapor charged with extraordinarily high energy and repeated contact with the concrete surface results in the formation of pits and holes, known as cavitation **erosion**. Since even a good-quality concrete will not be able to resist this kind of deterioration, the best remedy is therefore the elimination of cavitation by producing smooth hydraulic flow. Where necessary, the critical areas may be lined with materials having greater resistance to cavitation erosion.

In general, the resistance of concrete to erosion and abrasion increases with increase in strength. The use of a hard and tough aggregate tends to improve concrete resistance to wear.

Certain natural aggregates react chemically with the alkalis present in Portland cement. When this happens these aggregates expand or swell in resulting in cracking and disintegration of concrete.



### Volume change

Principal factors responsible for volume changes are the chemical combination of water and cement and the subsequent drying of concrete, variations in temperature and alternate wetting and drying. In the case of **fly ash** or **silica fume** mixed in the concrete, activation composition of **mineral admixture** and **calcium hydroxide** precipitation of cement hydrate have pozzolanic reaction and generate calcium silicate, which expands in volume ( Fig.3.2) .

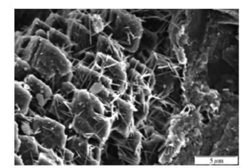



Fig.3.1 ITZ of concrete in $Na_2SO_4$ solution

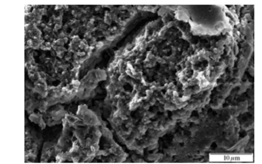



Fig.3.2 Hydrate of concrete with silica fume

When change in volume is resisted by internal or external forces, this can produce cracking, the greater the imposed restraint, the more severe the cracking. The presence of cracks in concrete

reduces its resistance to the action of leaching, corrosion of reinforcement, attack by sulphates and other chemicals, alkali-aggregate reaction and freezing and thawing, all of which may lead to disruption of concrete. Severe cracking can lead to complete disintegration of the concrete surface particularly when this is accompanied by alternate expansion and contraction.

Volume changes can be minimized by using suitable constituent materials and mix proportions having due regard to the size of structure. Adequate moist is also essential to minimize the effects of any volume changes.

## Permeability and Absorption

Permeability refers to the ease with which can pass through the concrete. This should not be confused with the absorption property of concrete and the two are not necessarily related. Absorption may be defined as the ability of concrete to draw water into its voids. Low permeability is an important requirement for hydraulic structures and in some cases water tightness of concrete may be considered to be more significant than strength although, other conditions being equal, concrete of low permeability will also be strong and durable. A concrete which readily absorbs water is susceptible to deterioration.

Concrete is inherently a porous material. This arises from the use of water in excess of that required for the purpose of hydration in order to make the mix sufficiently workable and the difficulty of completely removing all the air from concrete during compaction. If the voids are interconnected concrete becomes pervious although with normal care concrete is sufficiently impermeable for most purposes. Concrete of low permeability can be obtained by suitable selection of its constituent materials and their proportions followed by careful placing, compaction and curing. In general, for a fully compacted concrete, the permeability decreases with decreasing water-cement ratio. Permeability is affected by both the fineness and the chemical composition of cement. Aggregates of low **porosity** are preferable when concrete with a low permeability is required. **Segregation** of the constituent materials during placing can adversely affect the impermeability of concrete.

The problems of concrete durability not only affect many properties of building materials, but also influence those goals of successive developments of a national environment. The concrete durability affects widely in many fields. It is pointed out that system theory method is favorable for researching the concrete durability and its evaluation with performance, structure, process and environment as a whole.



## Words and Phrases

durability [ˌdjuərəˈbiliti] *n.* 耐久性，耐久率，耐用性
deterioration [diˌtiəriəˈreiʃən] *n.* 恶化，损坏，退化
chloride [ˈklɔːraid] *n.* 氯化物，漂白剂
sulphate [ˈsʌlfeit] *n.* 硫酸盐
alkali [ˈælkəlai] *n.* 碱
absorption [əbˈsɔːpʃən] *n.* 吸收性，吸收
permeability [ˌpəːmiəˈbiliti] *n.* 渗透性，渗透率，穿透性
homogeneous [ˌhɔməuˈdʒiːnjəs] *adj.* 同类的，均质的，均相的

disruptive [dis'rʌptiv] *adj.* 破坏性的，制造混乱的
thaw [θɔː] *v.* 使融化，解冻
kerb [kəːb] *n.* 马路的边石
reservoir ['rezəvwɑː] *n.* 水库，蓄水池
compatible [kəm'pætəbl] *adj.* 相容的，能共处的
workability [ˌwəːkə'biliti] *n.* 和易性，可用性
deicing [ˌdiː'aisiŋ] *n.* 去冰，除冰
leaching ['liːtʃiŋ] *n.* 浸析，浸出
carbonation [kɑːbə'neiʃən] *n.* 碳化，碳酸盐法
cement paste 水泥浆
cavitation [ˌkævi'teiʃən] *n.* 气蚀，气穴，凹穴
abrasive [ə'breisiv] *adj.* 磨蚀的，磨平的；*n.*研磨剂
attrition [ə'triʃən] *n.* 磨损，磨耗
erosion [i'rəuʒən] *n.* 腐蚀，侵蚀
fly ash 粉煤灰
silica fume 硅粉
mineral admixture 矿物掺合料
calcium hydroxide 氢氧化钙
porosity [pɔː'rɔsiti] *n.* 孔隙率，多孔性
segregation [ˌsegri'geiʃən] *n.* 离析，分离

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The external causes ________ the effects of environmental and service conditions ________which concrete is subjected, such as ________, ________and________.

2. In general, for a fully compacted concrete, the permeability decreases with decreasing ________. ________is affected by both the fineness and the chemical composition of ________. Aggregates of low ________ are preferable when concrete with a low ________ is required.

3. If the voids are interconnected concrete becomes pervious although with normal care concrete is sufficiently ________ for most purposes. Concrete of low ________ can be obtained by suitable selection of its constituent materials and their ________ followed by careful ________, ________ and ________.

Ⅱ. Translate the following passages from English into Chinese.

There is a need for all structural engineers to develop an understanding of structural reliability theory and for this to be applied in design and construction, either indirectly through codes or by direct application in the case of special structures having large failure consequences, the aim in both cases being to achieve economy together with an appropriate degree of safety. The subject is now sufficiently well developed for it to be included as a formal part of the training of all civil and structural engineers, both at undergraduate and post-graduate levels. Concrete on structural safety have been given at some universities for a number of years.

Strength and permeability of hydrated cement paste are mutually related through the capillary porosity which is controlled by water-cement ratio and degree of hydration. In general, with the exception of freeze-thaw resistance, since durability of concrete is controlled mainly by its permeability, it is not difficult to understand why there is a direct relationship between strength and durability. Consequently, in routine mix design operations, only workability and strength are emphasized, consideration of durability is ignored unless special environmental exposures require it.

## 参 考 译 文

### 第3章 建 筑 材 料

Section A 土木工程材料

作为一名工程人员必须知道施工现场所用的建筑材料。所有的结构都是由材料建造成的，这些材料被称为工程材料或建筑材料。工程人员必须熟悉这些材料的特性。土木工程材料有天然的和人造的。它们包含水泥、金属、木材、混凝土和沥青等。除了这些传统材料外，新型建筑材料也将被研究和开发并逐步地利用。现在，基于可持续发展的需要，绿色土木工程材料甚至生态土木工程材料被推荐使用。采用这种材料带来的好处有降低能耗、节约资源、保护环境和降低对人体健康的危害。

**水泥**

水泥是石灰质和黏土质材料的混合物在很高的温度下被焙烧制成的。焙烧的产品被称为水泥熟料。少量的石膏被加入到水泥熟料中然后被粉碎成非常细的粉末称为水泥。当凝固时，水泥类似于砂岩，因为是在英国的波特兰被发现的，所以，又被称为波特兰水泥。

**水泥的种类**

通过改变化学组成以及不同原材料、外加剂的使用，制备不同类型的水泥可以满足有特殊目的的工程建设需求。快硬性水泥被用在初始阶段有高强度需求的工程中，如维修工程和早期模板的拆除等。低热水泥被用于水坝的建设等大体积混凝土工程中。火山灰质硅酸盐水泥的水化热很低，而且可以很好地抵抗水的侵蚀。引气水泥通过加入少量的引气剂和普通硅酸盐水泥混合来制备。通过加入引气剂，混凝土的特性被改变，它能够提高硬化混凝土的抗冻性。高强度水泥被用在某些特殊的工程中。为了提高混凝土的强度，高含量 $C_3S$ 和高细度的水泥混合用在普通硅酸盐水泥当中。这种水泥可用于铁路轨枕，预应力混凝土，预制混凝土和机场等工程中。

**混凝土**

在施工现场或附近，水泥和沙子、骨料(小石头，碎石或砾石)和水混合制成混凝土。混凝土有很高的抗压强度，并且它的强度取决于水泥、石子和水的混合比例。混凝土随着龄期而逐渐硬化，当混凝土已经达到足够的强度后，水化的过程还会持续一段很长的时间。

普通混凝土有相对较低的抗拉强度，对于结构应用来说，通常的做法是加入钢筋来抵抗拉力的作用(钢筋混凝土)或者是给混凝土施加压力来抵消这些拉力(先张法预应力混凝土或后张法预应力混凝土)。混凝土被用在建筑物的结构上，如壳结构、桥梁、污水处理工程、铁路枕木、道路、水坝、烟囱、港口、近海结构等。混凝土也被用在大范围的预制混凝土生产当中，包括混凝土砌块、外挂板和管道。

普通混凝土的抗冲击强度和抗拉强度是很低的，这可以通过在混凝土中随机引入乱向分

布的纤维来提高。钢纤维、聚丙烯纤维、石棉玻璃纤维、碳纤维甚至木纤维已经被成功地应用到预制产品和施工现场的混凝土中了，包括管道、建筑板和桩。

**木材**

木材是最古老的土木工程材料之一。除了作为结构材料使用外，它还能起到临时搭建物的作用。尽管木材是一种可再生资源，但是树木的生长速度相对较慢，因此森林的消耗速度必须减慢。

木材在楼地面、饰面、踢脚板、窗户、门、楼梯、镶板和家具上都有着很广泛的用途。为实现上述的用途，需要考虑工作和完成的难易、好的纹理和外观和在温度、湿度、内部和外部变化条件下的尺寸稳定性、抗虫害和真菌的侵蚀等。

如今，木材在脚手架木工作业中起的作用越来越重要了，如原位立模板，预制混凝土工作，为砖、石拱桥或壳的支模，或是胶合叠层木梁或壳形的夹具等。

**金属材料**

在土木工程中，金属材料的应用广泛而且多样，大到主要结构材料，小到连接件、轴承材料。金属具有独特的结构材料性能，高抗拉强度，能被制成钢板、断面、电线等，并具有焊接性能。金属还具有其他性能如导电性、高的导热性和金属光泽，在某些情况下这些特性都是很重要的。普通金属特别是钢筋，最大的缺点可能就是易受潮湿状况和大气的侵蚀，故需要被保护起来。

对结构材料来说，金属的重要性大多数与它们在抗拉或抗压中的承载能力和抵抗有限的变形而不致断裂的能力有关。通常采用拉伸试验来评估这些特性，在试验过程中，弹性模量、屈服应力、抗拉强度和伸长率都能通过测试确定。

那时，钢材基本上是由铁里面的合金和一小部分碳通过很费力的加工过程制得的。在1856年贝塞麦法发明后，钢材因价格较低才大量被使用。钢材最大的优点是抗拉强度，也就是说，当它在一定程度的拉力作用下，它的强度不会损失，通常如我们所看到的，这个拉力会使得很多其他材料被拉开。新的合金进一步提高了钢的强度并消除了一些问题，例如由于应力的不断变化而产生的疲劳，加入合金是解决这个问题的趋势。

**沥青**

工程师们已经能利用沥青优良的耐久性和黏聚性。沥青材料大部分是与矿物或其他骨料混合使用。最早知道的沥青和煤焦油的用途是和水力学应用有关的，例如，沥青被用在建筑物的防水层，将薄的沥青涂料或乳液应用到吸收材料上，对封闭毛细管有影响，这样就可以阻止水和水蒸气从材料通过。现今，沥青的主要用途是在路面上，称为沥青混凝土路面。为了提高沥青材料在高温下的强度和在低于零度以下冲击韧性，聚合物改性沥青，如SBS改性沥青和APP塑料改性沥青被广泛地应用。



## Section B 钢筋混凝土

在世界上的许多国家，混凝土和钢筋混凝土都被用作建筑材料。在包括美国和加拿大的许多国家，钢筋混凝土在工程结构中是一种主导结构材料。钢筋混凝土结构的特性就是源于钢筋、混凝土、砾石、沙子和水泥这些材料可以很容易获得，以及混凝土工程施工过程中相对简单的技术和与其他结构形式相比的经济性。混凝土和钢筋混凝土被用在桥梁和各类建筑物中，地下结构、水箱、电视塔、海上石油勘探和生产结构、大坝，甚至还用在船舶上。

众所周知，与较高的抗压强度相比，混凝土抗拉和抗弯强度相对较低，甚至在较低的应力作用下，混凝土也很容易开裂。在结构应用方面，通常的做法是利用钢筋来抵抗拉力。钢

筋用在混凝土当中，能够克服在混凝土拉伸和弯曲过程中的一些不足。混凝土可以通过现浇、泵送、甚至喷射制成各种形状。鉴于钢筋有较高的抗拉强度，混凝土有较高的抗压强度，因此，这两种材料可以相互补充。

与混凝土相比，钢筋的最大优点是抗拉强度；也就是说，它在一定的拉力作用下，钢筋的强度不损失，正如我们看到的，这个拉力能够使得许多材料被拉开。在普通的钢筋中，抗拉强度同抗压强度一样有用，如屈服强度，大约是普通结构混凝土抗压强度的 15 倍，是它的抗拉强度的 100 倍。因为混凝土抗拉强度的欠缺，钢筋是结构的重要部分。所以在结构中可以没有混凝土，但不能没有钢筋。另一方面，与混凝土相比，钢筋是一种高成本的材料。虽然钢筋只占钢筋混凝土体积的一小部分(大约是 2%)，但却占据成本的主要部分。粗略地计算，框架的成本，钢筋和混凝土的成本大致是一样的，均约占整个成本的 1/3。

如果混凝土被用来抵抗压应力和压力，纵向钢筋被放在受拉力一侧用来抵抗拉力，其他的附加钢筋用来抵抗由剪力引起的斜向拉应力，这样两种材料组合使用最佳，如钢筋混凝土梁。然而，在一些期望减少截面尺寸的受压构件中，钢筋通常也主要被用来抵抗压力，像用在多层建筑物中的低层柱中。即使没有这种必要，少量钢筋被用在所有的受压构件中可以保证它们免受小的附加弯矩的影响，这个弯矩能使得构件开裂甚至可能使得无筋构件破坏。

钢筋和混凝土还有另一个互补优势：它们的收缩率和扩张率几乎相同。因此在压力和拉力作用的情况下它们可以共同工作。

钢筋嵌入混凝土内形成钢筋混凝土，可用于有拉力产生的混凝土梁或结构中。混凝土和钢筋之间也形成很大的黏结力使钢筋不能从混凝土中滑出。同时，钢筋的直径应该足够小以提供钢筋与混凝土之间充足的接触面积；这表明了对于配筋率的结构，钢筋的直径越小，它们的接触面积越大。当钢筋的数量很多以至于要阻碍混凝土的合理浇注时，此时达到了钢筋直径的合适限值。

混凝土和钢筋之间形成一种强大的黏合力，这个力能够将它们黏结在一起使得周围混凝土和钢筋不产生相对的滑移。这种黏合力是由产生在钢筋混凝土表面的相对较大的化学附着力、热轧钢筋工厂的原始粗糙度以及带肋钢筋表面的间隔较小的变形所提供的，这种带肋钢筋主要是为了使两种材料有很高的联结。

钢筋混凝土还有一个优点是钢筋在混凝土中不会生锈，酸腐蚀钢筋，而混凝土有一个碱性化学反应，刚好与酸中和。在严重的暴露环境下，例如易遭受除冰盐的桥面，为了减小钢筋的腐蚀和随之而来的混凝土剥落，一些镀锌或环氧涂层钢筋被指定使用。

尽管结构是一个整体的，钢筋却不是。一个刚性钢框架结构的各组成部分是通过不同方式的焊接在一起的，同样在混凝土结构中，为了制造出刚性框架结构，这个框架的各组成部分被做成杆状。然而，这样做会是一个相当大的不必要的开支。因此，我们通常处理单一钢筋的时候，钢筋的长度不超过 12m(39 ft)，因为太长的钢筋不容易被运输。这些钢筋在混凝土中被联结，钢筋应力通过黏合力或锚具传递给混凝土，然后通过同样的方式再传递给另一根钢筋。这就有必要为钢筋提供足够的空间，使得钢筋通过在混凝土中传递来发展应力。

结构钢和钢筋混凝土的应用导致了传统结构做法的重大变革。在早期的钢筋混凝土的框架结构，幕墙通常是用石头做成的，它们有承重墙坚实的外观。然而在今天，幕墙通常是由轻质材料做成的，如玻璃、铝、塑料等不同材料的组合。多层建筑物的建造也不再需要用石头或砖来砌筑厚墙了，同时建造耐火的楼面板也变得很简单。这些改变都有助于减少工程造价，而且使建造高度更高、跨度更大的建筑物也变成了可能。

Section C 混凝土耐久性

现今，在各种严酷环境条件下和伴随许多混凝土技术发展新问题的出现，越来越多的由于缺乏耐久性而不是强度不足的工程破坏实例引起了人们对混凝土耐久性的关注。耐久性设计代替强度设计的观点越来越广泛地被人们所接受。

混凝土的耐久性被定义为抵抗外部和内部原因导致的恶化的能力。外部原因包括混凝土遭受的环境的影响和工作条件的影响，例如气候、化学作用和磨损。内部原因是盐的影响，特别是氯化物和硫酸盐，以及组成材料之间的相互作用，如碱骨料反应、体积变化、吸水性和渗透性。

为了生产高耐久性的混凝土，人们应该注意选择合适的材料组分。为生产均匀致密的混凝土，使各组分材料配比得当，这一点也是很重要的。

**冻融**

由气候带来的混凝土的劣化通常是由混凝土内部自由水的冻融交替、温度变异和干湿交替引起的抑制作用下混凝土的膨胀、收缩等引起的。

在冻期，由冻融循环导致的混凝土破坏是由孔隙水的膨胀引起的，在一个特定条件的限制下，如果冻融循环重复足够的次数，会导致水压力的发展有可能破坏混凝土。路肩和石板路，水坝和水库是非常容易遭受冻胀作用的结构。

混凝土耐冻融的能力可以通过提高混凝土的抗渗透性来改善。这可以通过采用尽可能低的水灰比来达到，但是必须具有经浇筑和捣实成内均匀体所需的和易性。混凝土的耐久性可以通过采用引气剂进一步改善，通常 3%～6%混凝土体积的含气量，可以满足大多数应用的要求。引气混凝土通常被用在撒除冰盐的路面上。

**化学侵蚀**

一般情况下，混凝土具有较低的耐化学侵蚀能力。很多化学制剂会与混凝土发生反应，但最常见的侵蚀有溶析、碳化作用和氯化物、硫酸盐侵蚀(如图 3.1)。化学物品主要与硬化水泥浆体的某种成分发生反应，因此，混凝土的耐化学侵蚀能力通常受水泥标号的影响。混凝土的耐化学侵蚀能力随着抗渗性的增强而明显改善。

**磨损**

混凝土磨损的主要原因是由快速流动的水、水里的磨损材料、风沙袭击和磨耗以及交通的影响。一定条件下的水压流量会导致流动的水和混凝土表面之间空隙的形成。这些空隙通常被有超高能量的水蒸气充满，由于与混凝土表面频繁接触，就导致了坑和洞的形成，称为气蚀。即使质量很好的混凝土也无法抗拒这种劣化，因此，最好的补救办法是通过制造光滑的液压流来消除气穴。如有必要，关键部位可以用有更好的耐气蚀材料作为内衬。

一般情况下，混凝土的耐侵蚀性和耐磨损性随着强度的增长而增长。使用坚硬和坚韧的骨料有助于提高混凝土的耐磨损性。

目前在普通硅酸盐水泥中，某些天然的骨料与碱发生化学反应。当这种反应发生的时候，这些骨料扩大或膨胀，导致混凝土的开裂和破碎。

**体积的改变**

对于体积的改变主要的影响因素是水和水泥的化学结合、随之而来的混凝土干燥以及温度的变异和干湿交替。当粉煤灰等矿物掺合料掺入混凝土时，其活性成分与水泥水化析出的氢氧化钙发生火山灰反应，生成体积胀大的硅酸钙水化物(如图 3.2)。

当混凝土体积的改变被内部或外部力抑制时，这将会产生裂缝，越是抑制，裂缝就越严

重。混凝土中裂缝的存在降低了它对溶析、钢筋锈蚀、硫酸盐和其他化学物质侵蚀、碱骨料反应和冻融损伤的抵抗力，从而导致混凝土破坏。特别是当伴有交替的膨胀和收缩的时候，严重的裂缝能导致混凝土彻底破碎。

体积的改变可以通过采用合适的材料组分以及与结构尺寸有关的配合比来减小。适当的湿度也能减小体积变化。

**吸水性和渗透性**

渗透性指水透过混凝土的难易程度，不能与混凝土的吸水性相混淆，二者没有必然的联系。吸水性可被定义为混凝土汲取水分进入孔洞的能力。对于水工结构，低渗透性是一个很重要的要求，在某些情况下，可以认为混凝土的不透水性比强度更为重要。其他条件相同的情况下，混凝土的低渗透性将会使其更耐久。容易吸收水分的混凝土更容易劣化。

混凝土本身就是多孔材料，这是因为在混合料中使用了比水化的需要量更多的水来使其具有足够的和易性，以及在捣实过程中空气难以完全从混凝土中排出。如果孔隙相互连通，混凝土就会变成透水的，但是正常养护的混凝土足以满足大多数结构的不透水性要求。低渗透性的混凝土可以通过选择合适的材料组分和比例并辅以精心浇筑、捣实和养护来实现。通常，对于充分捣实的混凝土，混凝土的渗透性随着水灰比的减小而降低。渗透性还受水泥的细度和化学成分的影响，低渗透混凝土应优先使用低孔隙率的骨料。在浇筑过程中，组成材料的离析会严重影响混凝土的抗渗性能。

混凝土耐久性的问题不仅影响建筑材料的许多性能，而且还影响国家环境的可持续发展目标。混凝土耐久性在许多领域影响颇为广泛。将性能、结构、过程和环境等作为一个整体的系统论方法来评估混凝土的耐久性被证明是有效的。

## Grammar：专业英语的特点(III)——结构特点

## Characteristics of English for Professional Purpose III—Structure Characteristics

上述文体特点和词汇特点是专业英语的基础。更进一步讲，还需要了解专业英语在段落及文章层面上的结构特点，了解隐含在语言运用中的逻辑思维过程。这样，才有助于学生把握文章要点和重点，提高阅读和理解能力。

一般的，在每一自然段落中，总有一个语句概括出该段落的重点。这个语句或在段落之首，或在段落中间。若干个自然段落会形成一个逻辑(或结构)段落，用以从不同角度来解说某一层面的核心内容。全篇则由若干个逻辑段落组成，从不同层面来阐述文章标题所表明的中心思想。

仔细阅读下面一篇短文(其中包括对土木工程的一些重要特性的说明)，分析其结构特点，并结合前面提到的语言、语法和词汇的特点，进一步体会专业英语的特点。

### Civil Engineering

① Engineering is the practical application of the finding of theoretical science so that they can be put to work for the benefit of mankind. Engineering is one of the oldest occupations in the history of mankind. Without the skills that are included in the field of engineering, our present-day civilization could never be evolved.

② Civil engineering is branch of engineering that deals with the design and construction of structures that are intended to be stationary, such as buildings and houses, dams, tunnels, bridges, canals, sanitation system and the stationary parts of transportation systems-highways, airports, port facilities, and road beds for railroads. Among its subdivisions are structural engineering, dealing with permanent structures; hydraulic engineering, dealing with the flow of water and other fluids, and environmental/sanitary engineering, dealing with water supply, water purification, and sewer systems; as well as urban planning and design. The term civil engineering originally came into use to distinguish it from military engineering. Civil engineering dealt with permanent structures for civilian use, whereas military engineering dealt with temporary structures for military use.

③ Civil engineering offers a particular challenge because almost every structure or system that is designed and built by civil engineers is unique. One structure rarely duplicates another exactly. Even when structures seem to identical, site requirements or other factors generally result in modification. Large structures like dams, bridges, or tunnels may differ substantially from previous structures.

④ An engineer is member of the engineering profession. The word engineer is used in two ways in English. One usage refers to the professional engineer who has a university degree and an education in mathematics, science, and one of the engineering special-ties. Engineer, however, is also used to refer to a person who operates or maintains an engine or machine. An excellent example is the railroad locomotive engineer, who operates a train. Engineers in this sense are essentially technicians rather than professional engineers.

⑤ Engineers must be willing to undergo a continual process of education and be able to work in other disciplines. They must also adapt themselves to two requirements of all engineering projects. First, the system that engineers produce must be workable not only from a technical but also from an economic point of view. This means that engineers must cooperate with management and government officials who are very cost-conscious. Therefore, engineers must accommodate their ideas to the financial realities of a project. Second, the public in general has become much more aware of the social and environmental consequences of engineering projects and of the hidden or delayed hazards in new products, processes, and many other aspects of civil engineering systems.

⑥ Engineers are required to have solid knowledge of mathematics, physics, and chemistry. Mathematics is very important in all branches of engineering. So it is greatly stressed. A current trend is to require students to take courses in the social sciences and the language arts. The work performed by an engineer affects society in many different and important ways, of which he or she should be aware. An engineer also needs a sufficient command of language to be able to write up his or her findings for scientific publications.

⑦ A civil engineer is a member of the civil engineering profession. They may work in research, design, construction supervision, maintenance, or even in sales or management. Each of these areas involves different duties, different emphases, and different uses of the engineer's knowledge and experience.

⑧ Much of the work of civil engineers is carried on outdoors, often in rugged and difficult terrain or under dangerous conditions. Surveying is an outdoor occupation, for example, and dams are often built in wild river valleys or gorges. Bridges, tunnels, and skyscrapers under construction

can also be dangerous places to work. In additions, the work must process under all kinds of weather conditions. The prospective civil engineer should be aware of the physical demands that will be made on him or her.

分析如下：

这篇文章共有八个自然段，介绍 civil engineering. 第一句就 engineering 一词进行了定义，因为段①讨论的是更高一层和的 engineering，它就形成第一个逻辑段。

接着，段②解释什么是 civil engineering，其结构的特征(to be stationary)分支(subdivision)情况，civil engineering 一词的来源(to distinguish it from military engineering)等。对结构的另外一个重要特性(unique)，则在段③加以阐述。这样，段②和段③就形成 civil engineering 层面的逻辑段。

段①开始定义 engineer,说明 engineer 一词的两种用法；在段⑤中，突出强调专业工程(professional engineers)所应注意的两方面的问题；段⑥则论述工程师应该掌握的知识和技能。这三段均以 engineer 为对象，形成第三个逻辑段。

从段⑦开始，就具体到 civil engineer；对土木工程实施的一个特点(outdoors)，在段⑧ 加以说明，并由此引出对 civil engineer 身体素质要求的评述。段⑦和段⑧组成最后一个逻辑段。

全文的逻辑关系是：围绕土木工程这一主体，内容从粗到细(engineering→civil engineering, engineer→civil engineer), (engineering→engineer, civil engineering→civil engineer).

# Chapter 4

## Mechanical Behavior of Materials

### Section A Mechanics of Materials

Mechanics of materials is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. This field of study is known by several names, including “strength of materials” and “mechanics of **deformable** bodies.” The solid bodies considered include **axially** loaded members, shafts in **torsion**, thin **shells**, beams, and columns, as well as structures that are assemblies of these components. In mechanics of engineering materials the members have shapes that either exist in actual structures or are being considered for their suitability as parts of proposed engineering structures. The materials in the members have propertied that are characteristic of commonly used engineering materials such as steel, aluminum, concrete, and wood.

As you can see already from the variety of materials, forces, and shapes mentioned, mechanics of engineering materials is of interest to all fields of engineering. The engineer used the principles of mechanics of materials to determine if the material properties and the dimensions of a member are adequate to ensure that it can carry its loads safely and without excessive **distortion**. In general, then, we are interested in both the safe load that a member can carry and the associated deformation. Engineering design would be a simple process if the designer could take into consideration the loads and the mechanical properties of the materials, manipulate an equation, and arrive at suitable dimensions. Design is seldom that simple.

Theoretical analyses and experimental results have equally important roles in the study of mechanics of materials. On many occasions, we will make logical derivations to obtain **formulas** and equations for predicting mechanical behavior, but we must recognize that these formulas cannot be used in a realistic way unless certain properties of the material are known. These properties are available to us only after suitable experiments have been carried out in the laboratory. Also, because many practical problems of great importance in engineering cannot be handled efficiently by theoretical means, experimental measurements become a necessity. Usually, on the basis of experience, the designer selects a trial member and then does an analysis to see if that member meets the specified requirements. Frequently, it does not and then a new trial member is selected and the analysis repeated. This design cycle continues until a satisfactory solution is obtained.

In general, the objectives of our analysis will be the determination of the stressed, **strains**, and **deflections** produced by the loads. If these quantities can be found for all values of load up to the **failure** load, then we will have a complete picture of the mechanical behavior of the body.

An important consideration in engineering design is the capacity of the object being designed

to support or transmit loads. Objects that must sustain loads include building structures, machines, aircraft, vehicles, ships, and a seemingly endless list of other man-made things. For simplicity, we will refer to all such objects as structures; thus, a structure is any object that must support or transmit loads.

If structural failure is to be avoided, the loads that a structure actually can support must be greater than the loads it will be required to sustain when in service. The ability of a structure to resist loads is called strength, hence the preceding **criterion** can be restated as follows: The actual strength of a structure must exceed the required strength. The ration of the actual strength to the required strength is called the **factor of safety** *n*:

$$\text{Factor of safety } n = \frac{actual \quad strength}{required \quad strength} \tag{4A-1}$$

Of course, the factor of safety must be greater than 1.0 if failure is to be avoided. Depending upon the circumstances, factors of safety from slightly above 1.0 are used.

The incorporation of factors of safety into design is not a simple matter, because both strength and failure have many different meanings. Failure can mean the **fracture** or complete **collapse** of a structure, or it can mean that the deformations have exceeded some limiting value so that the structure is no longer able to perform its intender functions. The latter kind of failure may occur at loads much smaller than those that cause actual collapse.

The determination of a factor of safety must also take into account such matters as the following: the probability of accidental overloading of the structure; the types of loads (**static**, **dynamic**, or repeated) and how accurately they are known; the possibility of fatigue failure; inaccuracies in construction; quality of workmanship; variations in properties of materials; deterioration due to corrosion or other environmental effects; accuracy of the methods of analysis; whether failure is gradual (ample warning ) or sudden (no warning); consequences of failure (minor damage or major catastrophe);and other such considerations. If the factor of safety too low, the likelihood of failure will be high and hence the structure will be unacceptable; if the factor is too large, the structure will be wasteful of materials and perhaps unsuitable for its function (for instance, it may be too heavy). Because of these complexities, good engineering judgment is required when establishing factors of safety. They are usually determined by groups of experienced engineers who write the **codes** and specifications used by other designers.

In actual practice, there are several ways in which factors of safety are defined and implemented. For many structures, it is important that the material remain within the **linear elastic range** in order to avoid permanent deformations when the loads are removed. Hence, a common method of design is to use a factor of safety with respect to yielding of the structure. The structure begins to yield when the yield stress, we obtain an **allowable stress**, of working stress, that must not be exceeded anywhere in the structure. Thus,

$$\text{Allowable stress} = \frac{\text{yield} \quad \text{stress}}{\text{factor} \quad \text{of} \quad \text{stress}}$$

Or

$$\sigma_{\text{allow}} = \frac{\sigma_{\text{y}}}{n} \tag{4A-2}$$

in which we have introduced the notations $\sigma_{allow}$ and $\sigma_y$ for the allowable and yield stresses, respectively. In building design, a typical factor of safety $n$ with respect to yielding is 1.67; thus, a **mild steel** having a yield stress $\sigma_y$ of 36 ksi has an allowable stress $\sigma_{allow}$ in tension of 21.6 ksi.

Another method of design is to establish the allowable stress by applying a factor of safety with respect to the **ultimate stress** instead of the yield stress. This method is suitable for brittle materials, such as concrete, and it also is used for wood. The allowable stress is obtained from the equation

$$\sigma_{allow} = \frac{\sigma_u}{n} \tag{4A-3}$$

in which $\sigma_u$ is the ultimate stress. The factor of safety is normally much greater with respect to the ultimate stress than with respect to the yield stress. In the case of mild steel, a factor of safety of 1.67 with respect to yielding corresponds to a factor of approximately 2.8 with respect to the ultimate stress.

The last method we will describe involves the application of factors of safety to loads rather than to stresses. We will use the term ultimate loads to mean the loads that produce failure or collapse of the structure. The loads that the structure must support in service are called service loads or working loads. The factor of safety is the ratio of the former to the latter:

$$\text{Factor of safety } n = \frac{\text{ultimate load}}{\text{service load}} \tag{4A-4}$$

In as much as service loads are known quantities, the usual design procedure is to multiply them by the factor of safety to obtain the ultimate loads. Then the structure is designed so that it can just sustain the ultimate loads. Then the structure is designed so that it can just sustain the ultimate loads at failure. This method of design is known as strength design, or ultimate-load design, and the factor of safety is called the load factor because it is a multiplier of the service loads:

$$\text{Ultimate load} = (\text{service load})\ (\text{load factor}) \tag{4A-5}$$

Typical load factors used in the design of reinforced concrete structures are 1.4 for dead load, which is the weight of the structure itself, and 1.7 for live loads, which are loads applied to the structure, The strength-design method is used regularly for reinforced concrete structures and occasionally for steel structures.

In aircraft design, it is customary to speak of the margin of safety rather than the factor of safety. The **margin** of safety is defined as the factor of safety minus one:

$$\text{Margin of safety} = n\text{-}1 \tag{4A-6}$$

Thus, a structure having an ultimate strength that is twice the required strength has a factor of safety of 2.0 and a margin of safety of 1.0. When the margin of safety is reduced to zero or less, the structure (presumably) will fail.

## Words and Phrases

deformable [ˌdiˈfɔːməbl] *adj.* 可变形的
axially [ˈæksiəli] *adv.* 轴向地
torsion [ˈtɔːʃən] *n.* 扭转，扭力
shell [ʃel] *n.* 壳体，壳层，壳

distortion [dis'tɔːʃən] *n.* 扭转，扭曲，翘曲，变形
formula ['fɔːmjulə] *n.* 公式，方程式，计算式准则，方案
strain [strein] *n.* 应变
deflection [di'flekʃən] *n.* 挠度，挠曲，偏离，偏差角
failure ['feiljə] *n.* 失效，失败，破裂，故障
criterion [krai'tiəriən] *n.* 准则，判据，标准
factor of safety 安全系数
fracture ['fræktʃə] *n.* 破裂，破碎，折断，断裂
collapse [kə'læps] *n.* 倒闭，坍；*v.*坍塌，陷落，倒塌，破坏
static ['stætik] *adj.* 静的，静力的，静电的
dynamic [dai'næmik] *adj.* 动态的，动力的，动力学的；电动的，冲击的
code [kəud] *n.* 规范，标准
linear elastic range 线弹性范围
allowable stress 允许应力
mild steel 低碳钢
ultimate stress 极限应力
margin ['mɑːdʒin] *n.* 边缘部分，页面的空白，栏外

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Mechanics of materials is a ________ of ________ that deals________ the behavior of solid bodies subjected ________various types of ________.

2. In general, the objectives of our analysis will be the determination ________the ________, ________, and ________produced ________ the loads.

3. ________ many structures, it is important that the material remain ________the ________________ in order to avoid permanent deformations when the ________ are removed.

Ⅱ. Translate the following passages from English into Chinese.

Superposition was presented as the preferred method for solving certain problems. However, becoming familiar with superposition was more important than finding solutions to the problems because superposition has application in many areas of stress analysis and will be used frequently in our future studies.

When studying mechanics of materials, you will find that your efforts are divided naturally into two parts: first, understanding the logical development of the concepts, and second, applying those concepts to practical situations. The former is accomplished by studying the derivations, discussions, and examples, and latter by solving problems. Some of the examples and problems are numerical in character, and others are algebraic (or symbolic).

## Section B Stress-strain Relationship of Materials

Every material undergoes deformation under the action of external forces or loads. Deformation, for example, change in **dimension** or in shape of the body or both **simultaneously**. While undergoing deformation, the particles of the material exert a resisting force. When this resisting force equals applied load, the **equilibrium condition** exists and hence deformation stops. This internal resistance is called the stress. The unit of stress is $N/m^2$.

The satisfactory performance of a structure frequently is determined by the amount of deformation or distortion that can be permitted. A deflection of a few thousands of an inch might make a boring machine useless, whereas the **boom** on a **dragline** might deflect several inches without **impairing** its usefulness. It is often necessary to relate the loads on a structure, or on a member in a structure, to the deflection the loads will produce. Such information can be obtained by plotting diagrams showing loads and deflections for each member and type of loading in a structure, but such **diagrams** will vary with the dimensions of the members, and it would be necessary to draw new diagrams each time the dimensions were varied. A more useful diagram is one showing the relation between the stress and strain. Such diagrams are called stress-strain diagrams.

Data for stress-strain diagrams are usually obtained by applying an axial load to a test specimen and measuring the load and deformation simultaneously. A testing machine is used to strain the specimen and to measure the load required to produce the strain. The stress is obtained by dividing the load by the initial **cross-sectional** area of the specimen. The area will change somewhat during the loading, and the stress obtained using the initial area is obviously not the exact stress occurring at higher loads. It is the stress most commonly used, however, in designing structures. The stress obtained by dividing the load by the actual area is frequently called the true stress and is useful in explaining the fundamental behavior of materials. The stress being defined as:

$$\text{stress}(\sigma) = \frac{\text{load}}{\text{area}} = \frac{P}{A} \tag{4B-1}$$

Stress $\sigma$ may thus be compressive or tensile depending on the nature of the load. When $P$ is in Newtons and $A$ is in square meters, stress $\sigma$, is in Newtons per square meter($N/m^2$), which is by definition Pascals (Pa).

Strain is a measure of the deformation produced by the application of external forces. Strain is measured as the ratio of the change in length, to the original length. It is the **linear** change in length per unit length. It is usually denoted by $\varepsilon$. The strain produced is defined as follows:

$$\text{strain}(\varepsilon) = \frac{\text{change in length}}{\text{original length}} = \frac{dl}{l} \tag{4B-2}$$

True strain, like true stress, is computed on the basis of the actual length of the test specimen during the test and is used primarily to study the fundamental properties of materials. Strains are usually relatively small in materials used in engineering structures, often less than 0.1%, and their accurate determination require special measuring equipment.

The difference between nominal stress and strain, computed from initial dimensions of the specimen, and true stress and strain is **negligible** for stresses usually encountered in engineering

structures, but sometimes the difference becomes important with larger stresses and strains.

The initial portion of the stress-strain diagram for most materials used in engineering structures is a straight line. The stress-strain diagrams for some materials, such as **gray cast iron** and concrete, show a slight curve even at very small stresses, but it is common practice to draw a straight line to average the data for the first part of the diagram and neglect the **curvature**. Thomas Young, 1807, suggested what amounts to using the ratio of stress to strain to measure the stiffness of a material. This ratio is given the symbol $E$ and termed **Young's modulus** or the modulus of elasticity and is the slope of the straight-line portion of the stress-strain diagram. Thus, Young's modulus is written as

$$E = \frac{\text{stress}}{\text{strain}} = \frac{\sigma}{\varepsilon} \tag{4B-3}$$

Young's modulus $E$ is generally assumed to be the same in tension or compression and for most engineering materials has a high numerical value. Typically, $E=200\times10^9$ N/m$^2$ for steel, so that it will be observed from Eq. that strains are normally very small. The actual value of Young's modulus for any materials is normally determined by carrying out a standard test on a specimen of the material.

The maximum stress for which stress and strain are **proportional** is called the proportional limit. The action is said to be elastic limit (or proportional limit for practical purposes), it is found that a portion of the deformation remains after the load is removed. The deformation remaining after an applied load is removed is called **plastic deformation**. Plastic deformation independent of the time duration of the applied load is known as **slip**. **Creep** is plastic deformation that continues to increase under a constant stress. In many instances creep continues until fracture occurs; however, in other instances the rate of creep decreases and approaches zero as a limit. Some materials are much more susceptible to creep than are others, but most materials used in engineering exhibit creep at elevated temperatures. The total strain is thus made up of elastic strain, possibly combined with plastic strain that results from slip, creep, or both. When the load is removed, the elastic portion of the strain is recovered, but the plastic part (slip and creep) remains as permanent set.

A precise value for the proportional limit is difficult to obtain, particularly when the transition of the stress-strain diagram from a straight line to a curve is gradual. For this reason, other measures of stress that can be used as a practical elastic limit are required. The yield point and the yield strength for a specified offset are frequently used for this purpose.

The yield point is the stress at which there is an appreciable increase in strain with no increase in stress, with the limitation that, if straining is continued, the stress will again increase.

The yield strength is defined as the stress that will induce a specified permanent set, usually 0.05 to 0.3 percent, which is equivalent to a strain of 0.0005 to 0.003. The yield strength is particularly useful for materials with on yield point.

We might take the obvious definition that a material has failed when it has broken into two or more parts. However, it has already been pointed out that in most applications a member would be unserviceable due to excessive distortion long before it actually ruptured. Consequently, we will relate failure to yielding and consider that a material has failed when it will no longer return to its original shape upon release of the loads. In a simple tensile test we would then say that a **ductile** material has failed when the material begins to yield. Then for uniaxial stress, failure occurs when the stress reaches the yield stress, in either tension or compression.

The maximum stress, based on the original area, developed in a material before rupture is called the ultimate strength of the material, and the term may be modified as the ultimate tensile, compressive, or shearing strength of the material. Ductile materials undergo considerable plastic tensile or shearing deformation before rupture. When the ultimate strength of a ductile material is reached, the cross-sectional area of the test specimen starts to decrease or **neck down**, and the resultant load that can be carried by the specimen decreases. Thus, the stress based on the original area decreases beyond the ultimate strength of the material, although the true stress continues to increase until rupture.

## Words and Phrases

dimension [di'menʃən] *n.* 大小，尺寸，维数，量纲
simultaneously [sɑiməl'teiniəsli] *adv.* 同时地
equilibrium condition 平衡条件
boom [buːm] *n.* 悬臂，吊杆
dragline ['dræglain] *n.* 拉牵，导索，拉铲挖土机
impair [im'pεə] *v.* 损害，损伤，断裂
diagram ['daiəgræm] *n.* 图表，图解，立体图
cross-sectional ['krɔs'sekʃənəl] *adj.* 横截面的
linear ['liniə] *adj.* 线的，线形的
negligible ['neglidʒəbl] *adj.* 可不计的，可忽视的
gray cast iron 灰口铸铁
curvature ['kəːvətʃə] *n.* 弧度，曲率，弯曲
Young's modulus 杨氏模量
proportional [prə'pɔːʃənəl] *adj.* 成比例的
plastic deformation 塑性变形
slip [slip] *n.* 滑动，滑移
creep [kriːp] *n.* 徐变，蠕变
ductile ['dʌktail] *adj.* (金属等)延性的，可延展的；(黏土等)可塑的，柔软的
neck down 颈缩



## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Data for stress-strain diagrams are usually obtained by ________an axial load ________a test specimen and measuring the ________ and ________ simultaneously.

2. The difference between nominal stress and strain, computed ________ initial dimensions of the specimen, and true ________ and ________ is negligible for stresses usually encountered in engineering structures, but sometimes the difference becomes important with larger ________ and ________.

3. The maximum stress, based ________ the original area, developed in a material before rupture is called the ultimate strength of the material, and the term may be modified as the ________, ________, or ________ of the material.

Ⅱ. Translate the following passages from English into Chinese.

In these cases we know that the stress is two-dimensional or biaxial and it may, in other cases, be three-dimensional, or triaxial. For a structure having biaxial or triaxial stresses, how should we check the safety of the design? The most obvious way would be to conduct tests in which specimens are stressed to failure in the same multiaxial manner as in the structure; the allowable multiaxial stress can then be determined by the application of an adequate safety factor. However, this would require a group of tests for every new set of multiaxial stresses that occurred in design.

In developing the various failure theories, we cannot avoid three-dimensional effects, but we will treat only those cases in which one of the stresses is zero, thus avoiding complications that would tend to obscure the important part of the theories. This is not a serious limitation, since in engineering practice most problems are reduced to the biaxial stress state for design. When shear stresses occur along with normal stresses, the principal stresses are determined. Thus, for practical purposes, we need to consider failure in a material subjected to two nonzero normal stresses while the third normal stress is zero.

## Section C Prestressed Concrete



Concrete is strong in compression, but weak in tension: its tensile strength varies from 8 to 14 percent of its compressive strength. Due to such a low tensile capacity, flexural cracks develop at early stages of loading. In order to reduce or prevent such cracks from developing, a **concentric** or **eccentric** force is imposed in the longitudinal direction of the structural element. This force prevents the cracks from developing by eliminating or considerably reducing the tensile stresses at the critical **midspan** and support sections at service load, thereby raising the bending, shear, and torsional capacities of the sections. The sections are then able to behave elastically, and almost the full capacity of the concrete in compression can be efficiently utilized across the entire depth of the concrete sections when all loads act on the structure.

The development of early cracks in reinforced concrete due to non-compatibility in the strains of steel and concrete was perhaps the starting point for the development of a new material like "prestressed concrete".

Prestressed concrete is not a new concept, dating back to 1872, when P.H. Jackson, an engineer from California, patented a prestressing system that used a tie rod to construct beams or arches from individual blocks. After a long lapse of time during which little progress was made because of the unavailability of high-strength steel to overcome prestress losses, R.E. Dill of Alexandria, Nebraska, recognized the effect of the shrinkage and creep (transverse material flow) of concrete on the loss of prestress. In the early 1920s, W.H.Hewett of Minneapolis developed the principles of circular prestressing.

Eugene Freyssinet proposed methods to overcome prestress losses through the use of high-strength and high-ductility steels in 1926-1928. In 1940, he introduced the new well-known and well-accepted Freyssinet system.

Prestressed concrete is an improved form of reinforcement. Steel rods are bent into the shapes

to give them the necessary degree of tensile strength. They are then used to prestress concrete, usually by one of two different methods. The first is to leave channels in a concrete beam that correspond to the shapes of the steel rods. When the rods are run through the channels, they are then bonded to the concrete by filling the channels with **grout**, a thin **mortar** of binding agent. In the other (and more common) method, the prestressed steel rods are placed in the lower part of a form that corresponds to the shape of the finished structure, and the concrete is poured around them. Two methods are referred to as "**pre-tensioned method**" and "**post-tensioned method**". Because prestressed concrete is so economical, it is a highly desirable material.

From the preceding discussion, it is plain that permanent stresses in the prestressed structural member are created before the full dead and live loads are applied in order to eliminate or considerably reduce the **net tensile stresses**. With reinforced concrete, it is assumed that the tensile strength of the concrete is negligible and disregarded. This is because the tensile forces resulting from the bending moments are resisted by the bond created in the reinforcement process. Cracking and deflection are therefore essentially irrecoverable in reinforced concrete once the member has reached its limit state at service load.

The reinforcement in the reinforced concrete member does not exert any force of its own on the member，contrary to the action of prestressing steel．The steel required to produce the prestressing force in the prestressed member actively preloads the member，permitting a relatively high controlled recovery of cracking and deflection．Once the flexural tensile strength of the concrete is exceeded，the prestressed member starts to act like a reinforced concrete element．

Two types of bond stress must be considered in the case of prestressed concrete. The first of these is referred to as "transfer bond stress" and has the function of transferring the force in a pre-tensioned tendon to the concrete. The second type of bond is termed "flexural bond stress" and comes into existence in pre-tensioned and bonded, post-tensioned members when the members are subjected to external loads.

Bond stresses also occur between the tendons and the concrete in both **pre-tensioned** and bonded, post-tensioned members, as a result of changes in the external load. There are of course no transfer bond stresses in post-tensioned members, since the end anchorage device relatively low in prestressed members for loads less than the cracking load, there is an abrupt and significant increase in these bond stresses after the cracking load is exceeded. Because of the **indeterminancy** which results from the plasticity of the concrete for loads exceeding the cracking load, accurate computation of the flexural-bond stresses cannot be made under such conditions. Again, testes must be relied upon as a guide for design.

Prestressed concrete uses less steel and less concrete. Due to the utilization of concrete in the tension zone, a saving of 15 to 30 percent in concrete is possible in comparison with reinforced concrete. The savings in steel are even higher, 60 to 80 percent, mainly due to the high permissible stresses allowed in the high tensile wires. Although there is considerable saving in the quantity of materials used in prestressed concrete members in comparison with reinforced concrete members, the economy in cost is not that significant due to the additional costs incurred for the high strength concrete high tensile steel, anchorages, and other hardware required for the production of

prestressed members. In spite of these additional costs, if a large enough number of precast units are manufactured. The difference between at least the initial costs of prestressed and reinforced concrete systems is usually not very large. And the indirect long-term savings are quite substantial, because less maintenance is needed, a longer working life is possible due to better quality control of the concrete, and lighter foundations are achieved due to the smaller cumulative weight of the superstructure.

The economy of prestressed concrete is also well established for long span structures. According to Dean, standardized precast bridge beams between 10 and 30 m long and precast prestressed piles have proved to be economical than steel and reinforced concrete in the United States. According to Abeles, precast prestressed concrete is economical for floors, roofs and bridges of spans up to 30 m and for cast in situ work, it applies to spans up to 100 m. In the long span range, prestressed concrete is generally economical in comparison with reinforced concrete and steel construction.

Prestressed concrete offers great technical advantages in comparison with other forms of construction, such as reinforced concrete and steel. In the case of fully prestressed members, free from tensile stresses under working loads, the cross-section is more efficiently utilized when compared with a reinforced concrete section which is cracked under working loads. Within certain limits, a permanent dead load may be counteracted by increasing the **eccentricity** of the prestressing force in a prestressed structural element, thus effecting saving in the use of materials.

A prestressed concrete **flexural member** is stiffer under working loads than a reinforced concrete member of the same depth. However, after the onset of cracking, the flexural behavior of a prestressed member is similar to that of a reinforced concrete member. Prestressed concrete members posses improved resistance to shearing forces, due to the effect of compressive prestress, which reduces principal tensile stress. The use of curved cables, particularly in long span members helps to reduce the shear forces developed at the support sections.

The use of high strength concrete and steel in prestressed members results in lighter and slender members than could be possible by using reinforced concrete. The two structural features of prestressed concrete, namely high strength concrete and freedom from cracks, contributes to the improved durability of the structure under aggressive environmental conditions. Prestressing of concrete improves the ability of the material for energy absorption under impact loads. The ability to resist repeated working loads has been proved to be as good in prestressed as in reinforced concrete.

Prestressed concrete has made it possible to develop buildings with unusual shapes, like some of the modern sports arenas, with large spaces unbroken by any obstructing supports. The uses for this relatively new structural method are constantly being developed.

Today, prestressed concrete is used in buildings，underground structures，TV towers，floating storage and offshore structures，power stations，nuclear reactor vessels，and numerous types of bridge systems including **segmental** and cable-stayed bridges．They demonstrate the **versatility** of the prestressing concept and its all—encompassing application. The success in the development and construction of all these structures has been due in no small measures to the advances in the technology of materials，particularly prestressing steel，and the accumulated knowledge in estimating the short-term and long-term losses in the prestressing forces．

## Words and Phrases

concentric [kɔn'sentrik] *adj.* 同心(轴)的(with)；集中的
eccentric [ik'sentrik] *adj.* 离心的，偏心的
midspan ['midspæn] *n.* 跨中
pre-tensioned method 先张法
post-tensioned method 后张法
grout [graut] *n.* 灰浆
mortar['mɔːtə] *n.* 砂浆，灰泥，水泥浆；*v.* 用灰泥涂抹
net tensile stress 纯拉应力
pretension [priː'tenʃən] *n.* 张拉
indeterminancy [indi'təːminənci] *n.* 不确定性
eccentricity [eksen'trisiti] *n.* 偏心，偏心距，离心率
flexural member 受弯构件
segmental [seg'mentl] *adj.* 分节的，分段的
versatility [ˌvəːsə'tiliti] *n.* 多方面适应性，多用性，多功能性

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. In order to reduce or prevent such cracks ________developing，a ________ or ________ force is imposed in the longitudinal direction ________ the structural element.

2. The development of early cracks in reinforced concrete ________ non-compatibility in the strains of steel and concrete was perhaps the starting point for the development of a new material like "________".

3. ________concrete offers great technical advantages ________other forms of construction, such as reinforced concrete and steel.

Ⅱ. Translate the following passages from English into Chinese.

In the precast and prestressed concrete industries，the use of high-strength concrete has resulted in a rapid turnover of molds，higher productivity, and less loss of products during handling and transportation．Since their permeability is very low，high-strength concretes also find application where durability of concrete is adversely affected due to abrasion，erosion，or various chemical attacks．

In ordinary reinforced concrete the economic advantage is not as pronounced as in prestressed concrete．The prestressing force in most cases is computed strictly from the dead load of the structure；consequently，a weight reduction of 25 percent results in a substantial reduction in the weight of prestressing tendons．Among other advantages of reduction in weight of concrete is the superior resistance of shear elements to earthquake loading since seismic forces are largely a direct function of the dead weight of a structure．

# 参 考 译 文

## 第 4 章　材料的力学行为

### Section A　材料力学

材料力学是一门应用力学，能够对固体机构受到不同类型的负荷进行处理。这一领域的研究通过这么几个名字为大家所知，包括“材料强度”和“力学变形体系”。固体机构包括轴心受压体系，轴向扭转，薄壳，梁和柱以及类似这些构件的结构体系。在工程材料中的力学模型，可以是在实际结构中已有的或是考虑适合作为拟建工程结构的部分。用于工程中的材料有共同的特点，常用的如钢铁、铝、水泥和木材等。

正如你已经从各种不同的材料、应力和提到模型中看到的，工程材料力学涉及各个工程领域。工程师运用材料力学的原理，确定材料特性和构件尺寸以确保它能够安全负载而不过度变形。一般情况下，我们感兴趣的不仅是构件的安全荷载，还有相关的变形。如果设计师考虑荷载和材料的力学性能，求解方程，得出合适的尺寸，那么工程设计将是一个简单的过程，但设计很少这么简单。

理论分析和实验结果对研究材料力学有同样重要的作用。在许多情况下，我们将得出符合逻辑的推导公式和方程，并对力学行为进行预测，但我们必须认识到，这些公式在现实方法中不能被使用，除非材料的某些性能是已知的。这些属性只有在实验室进行实验以后才能够获得。此外，在很重要的工程当中，很多实际问题按理论的方法不能有效解决，因此，实验测量是很有必要的。通常在经验基础上，设计师选择一个试验构件，然后分析它是否能够满足特定的要求。通常情况下，要是这个构件不满足，就会选一个新的试验构件并重新进行分析。这样的设计周期将持续到获得一个令人满意的解决办法为止。

一般情况下，我们分析的目标是确定应力、应变和荷载引起的挠度。如果可以找到导致破坏荷载的所有荷载值，那么我们将有一个体系的力学行为的完整构图。

在工程设计中，一个很重要的问题是考虑物体支撑或传递荷载的能力。负载物体包括建筑结构、机器、飞机、车辆、船舶，以及似乎永无休止的其他人造的物体。为了简便起见，我们将提到的所有这些物体视为结构；因此，结构可以是承受或传递荷载的任何物体。

如果结构的失效能够避免的话，结构的承载能力实际上可以比正常使用时更大。结构抗负荷的能力称为强度，因此上述标准可以表述为：结构的实际强度必须超过所要求的应力。实际应力与所需应力的比值称为安全系数 $n$：

$$\text{安全系数 } n=\frac{\text{实际应力}}{\text{所需应力}} \tag{4A-1}$$

当然，若为避免失效，安全系数必须大于 1.0 。基于这种情况，使用时安全系数应按略高于 1.0 考虑。

把安全系数纳入设计不是一件简单的事，因为强度和失效有很多不同的含义。失效可能意味着破裂或结构的彻底坍塌，也可能意味着一些变形已超过限定值以至于这样的结构已不再能够履行既定的功能。后者的失效可能出现在负荷远低于引起实际破坏时的负荷值。

确定一个安全系数也必须考虑到如下这些事项：结构偶尔超载的可能性；负载的类型(静态、动态或重复)，以及如何准确地知道它们；疲劳破坏的可能性；施工时的不确定性；工艺质量；材料性能的变化；由于腐蚀或其他环境影响引起的劣化；分析方法的正确性；失效是

否是渐进的(足够的预兆)或突然的(没有预兆)；失效的后果(轻微损坏或重大灾难)；以及其他此类因素。如果安全系数太低，失效的可能性将很高，因此，这样的结构将是不能接受的；如果系数过大，结构将浪费材料，而且可能不适合履行它的功能(例如，它可能过重)。由于这些复杂性，建立安全系数时需要良好的工程判断，它们通常是由经验丰富的编写规范的工程师决定的，而这些规范是设计师在设计过程中使用的。

在实际工程中，有几种确定和实施安全系数的方法。对于许多结构，重要的是，卸除载荷时这些材料仍在弹性线性范围内，从而避免永久变形。因此，通常的设计方法是使用与结构屈服对应的安全系数。结构达到屈服应力时开始产生屈服，我们会取得一个允许的工作应力，这个应力不能超过结构任何地方所能承受的压应力，因而：

$$\text{允许应力}=\frac{\text{屈服应力}}{\text{应力系数}}$$

或者

$$\sigma_{\text{allow}}=\frac{\sigma_{\text{y}}}{n} \tag{4A-2}$$

式(4A-2)引出了 $\sigma_{\text{allow}}$ 和 $\sigma_{\text{y}}$，分别表示允许应力和屈服应力。在建筑设计中，一个典型的安全系数 $n$ 对应的屈服应力为 1.67；因此，低碳钢屈服应力为 36 ksi(kilopound per square inch，即每平方英寸的千磅数，1 ksi=1000 lb/in$^2$=6.8 N/mm$^2$)，对应有一个允许拉应力 21.6 ksi 。

另一种设计方法是通过应用与极限应力而不是屈服应力对应的安全系数。这种方法适用于脆性材料(如混凝土)，也可用于木材。允许应力是从方程(4A−3)中获得

$$\sigma_{\text{allow}}=\frac{\sigma_{\text{u}}}{n} \tag{4A-3}$$

式中, $\sigma_{\text{u}}$ 是极限应力。极限应力对应的安全系数通常远远大于屈服应力所对应的安全系数。对于低碳钢，屈服应力对应的安全系数是 1.67，而极限应力对应的安全系数大约是 2.8。

我们谈到的最后一种方法是关于荷载安全系数的应用而不是应力安全系数的应用。我们将使用的极限荷载这一术语意味着结构的断裂或倒塌。结构在使用期间必需承受的荷载称为使用荷载或工作荷载。安全系数就是前者和后者的比值，公式为

$$\text{安全系数 } n=\frac{\text{极限荷载}}{\text{工作荷载}} \tag{4A-4}$$

在大家都知道的工作荷载中，通常的设计步骤是用安全系数乘以工作荷载得出极限荷载。结构被按照能够承担其极限荷载来设计。这样，所设计的结构正好能够保证在破坏时能够承担极限荷载。这种设计方法被称作强度设计或极限荷载设计，安全系数被称为荷载系数，因为它是工作荷载的乘数：

$$\text{极限荷载}=\text{工作荷载}\times\text{荷载系数} \tag{4A-5}$$

典型的荷载系数在设计钢筋混凝土中使用，恒载为，即结构本身的重量为 1.4，作用于结构中的活载为 1.7，这种强度设计方法经常用于钢筋混凝土结构中，有时也用于钢结构中。

在飞机设计中，习惯讲的是安全限度而不是安全系数。安全限度被定义为安全系数减去1，即

$$\text{安全限度}=\text{安全系数 } n-1 \tag{4A-6}$$

因此，结构所具有安全系数为 2.0 的极限强度是安全限度为 1.0 的 2 倍。安全限度减小为 0 或更小，结构就垮了。

Section B　材料的应力应变关系

任何材料在外力或荷载的作用下都要变形。例如，变形有尺寸的改变或形体的变化或二者同时进行。经历变形的同时，材料各部分会产生抵抗力。当这种抗力等于载荷时，平衡条件就存在，而且变形就停止。这种内部抵抗叫做应力。该应力的单位是 $N/m^2$ 。

结构令人满意的表现通常是由其允许大的变形和扭曲决定的。变形几千分之一英寸就有可能使钻床毫无用处，而挖土机的悬臂可能偏移几英寸也不会损害其效用。关心结构上或构件上的荷载以及荷载产生的挠度是必要的。这些信息的获得是通过绘制表格来表示构件的荷载和变形以及在结构上的荷载类型。但是这种图表随着构件尺寸的变化而变化，所以每次尺寸变化的时候绘制新表格是有必要的。显示应力和应变关系的图更有用，这种图表被称为应力应变图。

通常应力应变图表的数据是根据轴向载荷作用到试件上，测量荷载和同时发生的变形来获得的。测试机是用来测量产生应变的试样的荷载。应力是通过试样的荷载除以初始横截面积得出的。在加载的过程中，这个面积是变化的，使用初始面积获得应力是明显的，不是更高的荷载出现时的准确应力。在结构设计中，最常用到的是应力。通过荷载除以实际面积而得到的应力通常叫做实际应力，这种应力对解释材料的基本行为很有用处。应力被定义为

$$\text{应力}\sigma=\frac{\text{载荷}}{\text{面积}}=\frac{P}{A} \tag{4B-1}$$

应力 $\sigma$ 的压缩或拉伸取决于荷载的性质。荷载 $P$ 的单位是 N，而面积 $A$ 的单位是 $m^2$，应力的单位是 $N/m^2$ ，即 Pa。

应变是衡量应用外部力而产生变形的。应变是用长度的变化除以原始长度的比率来衡量的。每单位长度的变化是线性变化。它就是通常所指的 $\varepsilon$ 。应变的产生的定义如下：

$$\text{应变}\varepsilon=\frac{\text{长度的变化}}{\text{原始长度}}=\frac{dl}{l} \tag{4B-2}$$

真正的应变和实际应力一样，是在实验当中试样的实际长度的基础上计算出来的，而且主要用来研究材料的基本性能。用于工程结构中的材料，应变相对较小，通常低于 0.1%，需要使用特殊的测量设备才能准确地计算出来。

名义应力和应变之间的差异，是从试样初始的尺寸中算出的。而通常在遇到的工程结构中，实际的应力和应变是可以忽略的，但有时候在较大的应力应变中这种差异就变得很重要。

在工程结构中使用的大部分材料最初的应力应变图是直线型的。一些材料的应力应变图，例如灰口铸铁和混凝土，即使应力非常小也会呈现轻微曲线，但通常的做法是利用图表第一部分的平均数据绘制直线，且忽略弯曲。1807 年，托马斯·杨，建议使用应力应变比率测量材料的刚度。符号 $E$ 表示了这个比率，称为杨氏模量或弹性模量，是应力应变图的初始直线部分的斜率。因此，杨氏模量被写为

$$E=\frac{\text{应力}}{\text{应变}}=\frac{\sigma}{\varepsilon} \tag{4B-3}$$

一般认为，对于大多数工程材料，在具有相同拉力或压力下，杨氏模量 $E$ 具有很高的数值。典型地，如 $E= 200 \times 10^9\ N/m^2$ 的钢，从式(4B-3)中，可观察到的应变通常很小。对于任何材料的实际杨氏模量，通常是由材料样本的标准测试来确定的。

应力最大时，应力和应变的比例被称为比例极限。该作用被认为是弹性极限(或实际应用的比例极限)，我们发现荷载卸掉后仍有一部分变形保留，这种荷载被移除后保持的变形叫做

塑性变形。不取决于加载的持续时间的塑性变形被称为滑移。徐变就是应力持续时不断增加的塑性变形。在许多情况下，徐变会一直持续到断裂发生，但是，在其他情况下，徐变率降低而且一直接近到 0 作为极限。有些材料比其他材料更容易发生徐变，但是工程中，大部分材料在温度升高时表现出徐变。这样，应变包含了弹性应变、滑移导致的塑性应变，徐变或者两者皆有。当荷载被移走时，应变的弹性部分恢复，但塑性应变部分(滑移和徐变)却会永久保留。

比例极限的精确值是很难获得的，尤其是在应力应变图由直线逐渐变为曲线的过渡时候。出于这个原因，其他一些在实用弹性极限中使用的应力测量方法是必需的。通常出于这一目的，使用屈服点和屈服强度来作为补偿。

屈服点是在应变有可观增加，应力没有增加的应力极限，在这个极限下，如果应变继续增加，应力就也会增加。

屈服强度的定义是应力会产生特定的永久变形，通常是 0.05%～0.3%，这相当于 0.0005～0.003 的应变 。在屈服点，材料的屈服强度尤其有用。

对一种被破坏为两部分或更多部分的材料，我们会采取明确的定义。但是，已经指出，大多数应用的材料中，一个构件在破裂之前，由于长期过度变形将不能使用。因此，我们将失效和屈服联系起来，认为当这种材料在卸载时不能恢复原来的形状时，材料已经破坏。在一个简单的拉伸试验中，我们会说，当材料开始屈服时，韧性材料就已经失效了。对于单轴应力来说，不管拉力或压力，当应力达到屈服应力时，破坏就发生了。

材料在原始面积基础上破裂之前发展的最大应力，称为材料的极限强度，这个术语被修正为材料的极限抗拉强度、抗压强度、抗剪强度。在破裂之前，韧性材料经历相当的塑性拉伸或剪切变形。当达到韧性材料的极限强度时，测试试样的横截面积开始减小或颈缩，由试样承担的荷载会减小。这样，超过了材料的极限强度时在原始面积基础上的应力就减小，虽然真正的应力会继续增加直至材料破裂。

Section C 预应力混凝土

混凝土的抗压强度很高，但抗压强度却很低：其抗拉强度是抗压强度的 8%～14%。由于这种较低的抗拉能力，在加载的早期阶段，就容易产生弯曲裂缝。为了减少或阻止这些裂缝的发展，在结构构件的纵向施加同心或偏心力。在荷载作用下，这个力能够消除或大大减少跨中关键部位和支座部位的拉伸应力，从而减少裂缝的发展，提高截面的抗弯、抗剪以及抗扭能力。这样，构件能表现出弹性性质，当全部荷载作用于结构时，混凝土构件的全部断面的抗压能力都能够被充分有效地发挥出来。

由于钢筋混凝土应变的不兼容性而导致混凝土早期裂缝的发展很可能是发展像预应力混凝土这样新型材料的出发点。

预应力混凝土不是一个新事物，可追溯到 1872 年，当时来自加州的一个工程师 P・H・杰克森申请了一项预应力系统的专利，他用拉杆把单个的块体建造成了梁或拱。由于在克服预应力损失方面高强度钢筋没有效果，在很长一段时间预应力研究进展很小，R.E. Dill 和 Nebraska 揭示了混凝土的收缩和徐变(材料横向流变)对预应力损失的影响。在 20 世纪 20 年代早期，美国明尼阿波利斯市的 W. H. Hewett 发展了环向预应力原理。

尤金・弗雷西奈于 1926—1928 年间提出了高强度和高延性钢的使用，能克服预应力损失。在 1940 年，他提出了现在众所周知并被普遍认可的弗雷西奈预应力法。

预应力混凝土是钢筋混凝土的一个改进形式，钢筋被弯成一定的形状并给它一定的拉力，




然后用先张法或后张法进行预压混凝土。第一种是留下对应钢筋形状混凝土梁的孔道。当钢筋穿过孔道时，梁用水泥浆填满孔道，薄薄的砂浆就与梁黏合在一起。另一种(更常见)方法，把预应力钢筋放在与成品结构的形状对应的模板的较低部分，并把混凝土浇灌在其周围。这两种方法被称为“先张法”和“后张法”。预应力混凝土因为节省钢材和混凝土，所以是理想、经济的建筑材料。

从前面的讨论中可以清楚地看到，为了消除或大大减少荷载在预应力单元上引起的纯拉应力，在它们承受整个的恒载和活载前，就预先给它们施加一个永久的预压应力。在一般的钢筋混凝土结构中，通常认为混凝土的抗拉强度是可以忽略或不计的，这是因为弯矩产生的拉应力由加筋处理后的黏合层来抵抗。因此，钢筋混凝土结构在工作荷载下达到极限状态后产生的裂纹和挠曲变形不可恢复。

和预应力钢筋的作用相反，普通钢筋混凝土构件中的钢筋不对构件施加任何的力。在预应力构件中，钢筋要通过预应力作用给构件主动施加预载，使构件对裂缝和变形有相对较高的恢复控制能力。一旦预应力构件受力使混凝土超过了其抗弯强度，则构件开始表现出钢筋混凝土构件的性质。

在预应力混凝土中，我们应该考虑两种类型的黏结应力。第一种类型可以被认为是“传递黏结应力”，而且具有传递钢筋的预张力给混凝土的功能。第二种类型的黏结力被称为“弯曲黏结应力”，当后张构件受到外部载荷时，这种应力存在于预张力和黏结力以及后张构件当中。

当外部荷载变化时，黏结应力也发生在钢筋和混凝土张拉和黏结当中。当然，在后张构件中，没有传递黏结应力，因为预应力构件端部锚固装置相对较低，故开裂荷载较小，在超出开裂荷载以后，黏结应力有一个突然急剧的增加。因为对超出开裂荷载的混凝土的塑性引起的结果尚不明确，所以在这种情况下，对弯曲黏结应力不能准确计算。此外，设计必须依赖试验，并指导设计。

预应力混凝土使用的钢筋和混凝土较少。由于在受拉区域使用混凝土，和钢筋混凝土相比，可能节省 15%～30%的混凝土。而钢筋节省会更多，约为 60%～80%，主要是因为在高抗拉钢筋中，允许应力也高。和钢筋混凝土相比，预应力混凝土尽管能够节省相当数量的材料，但是经济成本并没有显著降低，因为高强混凝土、高强钢筋、锚固以及满足预应力构件生产的硬件要求都会导致附加的费用。尽管有这些附加的费用，通常情况下，如果生产的预制构件在数量上足够多的话，预应力构件和钢筋混凝土构件相比，至少最初直接成本的差异不是太大。但因为预应力构件不需要太多的维护：一是因为混凝土质量好，它的使用寿命长，而且由于上部结构的累积荷重较小，基础重量也相应轻得多，所以从长期来看，间接费用的节约还是巨大的。

预应力混凝土的经济性也可以通过大跨度结构得以证明。根据迪安原理，在美国长 10 m 到 30 m 的标准预制桥梁箱梁和预制预应力桩已经证明比用钢和钢筋混凝土更经济。据 Abeles 理论，预制预应力混凝土地板、屋顶、跨度达 30 m 的桥梁是经济的；而现浇则对跨度达到 100 m 才更经济。在大跨度结构中，与钢筋混凝土以及钢结构施工相比，通常预应力混凝土更经济。

与其他的施工方式相比，预应力混凝土提供了更大的技术优势，比如说钢筋混凝土和钢结构。以完全预应力构件为例，工作荷载下不受拉应力，和在工作荷载下带裂缝的钢筋混凝土截面相比，其横截面积可以更有效的利用。在一定的范围内，预应力结构构件中预应力偏心距的增加可抵消永久荷载，从而有效节约使用材料。

预应力混凝土受弯构件在荷载作用下在工作载荷下比同样高度的钢筋混凝土构件具有更

大的刚度。然而，一旦发生开裂，预应力构件和钢筋混凝土构件的弯曲行为相似。预应力混凝土构件提高了抗剪能力，因为预压应力的影响，减少了主拉应力。使用弯曲钢筋，特别是在大跨度结构中，有助于减少在支座截面的剪力的发展。

使用高强混凝土和钢筋的预应力构件比钢筋混凝土构件更轻质更细长。预应力混凝土的两个特点，即为高强度和无裂缝，归因于在外部侵蚀环境下结构耐久性的提高。混凝土的预应力提高了材料在冲击荷载下对能量吸收的能力，像钢筋混凝土一样，预应力混凝土也具有很高的抵抗重复荷载的能力。

预应力混凝土可用于建造特殊形态的建筑物，像一些没有支柱支撑的大空间的现代体育场馆。这种相对较新的构造方法的使用正不断发展。

今天，预应力混凝土被用于建筑物、地下结构、电视塔、浮动储藏器和海上结构、电站、核反应堆容器和包括拱形桥和斜拉桥在内的各种桥梁系统中，这些说明了预应力概念的多方面适应性以及对它的广泛应用。所有这些结构的发展和建造的成功都是由于材料技术进步所获得的无法计量的收获，特别是预应力钢和在估计预应力长期和短期损失方面累积的知识。

## Grammar：专业英语翻译技巧(I)——概述

### Translation Skills of English for Professional Purpose I—Summary



1. 翻译原则

(1) 了解相关专业知识。

由于专业英语涉及自然科学与社会科学的各个领域，内容广泛，专业性较强。因此译者应有较宽的知识面，了解不同专业的专业术语，掌握不同学科的一些基本的专业知识。

(2) 准确理解词义。

要注意那些常用词在特定学科中的特定含义，不可以常义代特定义，但同时也不应将所有的常用词全部作为专业或准专业词理解，翻译中不仅要勤查词典，而且更要结合一个词的上下文及所在专业领域来确定其真实含义。而且，科学技术发展迅速，相应的新词不断出现，译者应随时关注相关领域的最新动态与发展，同时要勤于动手动脑，这样才能准确理解并再现那些新词的意义。

(3) 仔细分析长句。

专业英语中有大量长句，这些长句中往往又含有若干分句和许多短语及其他修饰限定成分，翻译时首先必须对长句进行深入细致的分析，先理清主干、再层层明确各成分之间的语法关系和语义逻辑关系，表达时一定要将意义的准确性和明晰性放在首位，该断句就断句，该增减就增减，不可死扣原文形式。

(4) 用词要得体。

一般来讲，专业英语语体较为正式，因此翻译时要尽可能选择与该文体相当的较为正式的词语，行文要向严谨规范的书面语靠拢。此外，原文因内容与功能的不同，在语气的正式程度上也会有所不同，阅读对象的接受能力和文化层次也各异。因此，翻译时应先对原文的正式程度和译文的潜在读者进行一番分析，以求得译文和原文在文体和功能上最大程度的对等。

2. 翻译标准

对专业英语的翻译，应以什么为标准，著名翻译家严复曾提出“信、达、雅”三字原则。

“信”指的是忠实于原文，不偏离原意。译者不能随意添加自己的意思或减少文中的某些表达。“达”指的是译文通顺，读者能看懂。语言要符合汉语的表达习惯。“雅”指的是译文要保存原文优美的语言风格，用词准确，修辞合理。基于这三字原则，译者在专业英语的翻译过程中尤其要做到准确、简洁、清晰。

(1) 准确。

所谓准确，就是要表达明确、准确，要正确理解和分析英语和语法特点与句型，表达上不使用模棱两可的词。

**【例 1】**Civil engineering offers a particular challenge because almost every structure or system that is designed and built by civil engineers is unique. One structure rarely duplicates another exactly. 土木工程提出了特殊的挑战，因为由土木工程师设计建造的每个结构或系统都是唯一的。一个结构几乎不能完全复制成为另一个。

(2) 简洁。

专业英语的内容通常包括理论分析、公式推导和研究的目的、范围、方法、步骤、结论等。在不影响表达的前提下，语言应尽可能简洁。避免不必要的润饰和重复，但并不排除会使用复杂句或长句。即语言简练，不重润饰。

**【例 2】** The yield criterion for a material is a mathematical description of the combinations of stresses which would cause yield of the material. In other words it is a relationship between applied stresses and “strength”. The yield criterion can be written:

$$F(\sigma_1,\sigma_2,\sigma_3,f_y)=0$$

where $\sigma_1$ , $\sigma_2$ , $\sigma_3$ are the principal stresses, and $f_y$ is the yield stress. When $F<0$, yield does not occur and if rigid-plastic material properties are assumed, there are no deformations. If $F=0$, yield occurs.

材料的屈服准则指可能导致材料屈服的应力组合的数学表达式。换句话说，它表示作用应力与“强度”之间的关系。屈服准则可写成

$$F(\sigma_1,\sigma_2,\sigma_3,f_y)=0$$

式中，$\sigma_1$，$\sigma_2$，$\sigma_3$为主应力，$f_y$为屈服应力。当$F<0$时，不会发生屈服，若材料为刚塑性，则也无变形。若$F=0$，屈服就发生。

(3) 清晰。

清晰主要是强调逻辑严谨，概念清晰，关系分明，句子连贯等。

**【例 3】** The materials are the basic elements of any building. Building materials may be classified into three groups, according to the purposes they are used for. Structural materials are those that hold the building up, keep it rigid, form its outer covering of walls and roof, and divide its interior into rooms. In the second group are materials for the equipment inside the building, such as the plumbing, and lighting systems. Finally, there are materials that are used to protect or decorate the structural materials.

材料是任何建筑的基本元素。根据使用目的，建筑材料被分成三组。结构材料用来支撑建筑物，保持其坚固，形成墙和屋面的外部围护，分隔内部房间。第二组材料是建筑内部的设备，如垂直运输、加热和提升系统。最后一组是用于保护和装饰的建筑材料。

# Chapter 5

# Load and Design Process

## Section A Principles of Structure Design

An architect draws up plans for a building to meet the **client**'s requirements. The structural engineer examines various arrangements and carries out **preliminary** designs to determine which is the most economical. All structural design is controlled by **specifications**. Even if no limitation is placed upon the designer, he will still be very likely to depend upon a standard set of specifications for guidance. All large cities have building **codes** that specify not only working stress but also other features of other structures. A standard set of specifications may be accepted to represent the best information available on the subject. The designer will follow the specifications of the local building code by necessity. All structures must be designed to support loads without danger of overall collapse or failure of the components.

There is no tool that has proved of greater value to the designer than the theory of **elasticity**. The distribution of stress presented by this theory is the picture that would apply before any single particle had passed the yield point. As soon as any part of the structure begins to yield, the distribution of stress will change. The plastic design is wholly dependent for its validity upon the formation of **plastic hinges** requiring considerable ductility of the material. By use of an appropriate factor of safety in **plastic design**, one may design ordinary continuous beams and frames for collapse loading with full confidence that a logical and balanced design will be achieved. For a given arrangement, the problem in structural design is

1. Estimation of loading;
2. Determination of stresses and strains in structures;
3. Design of elements and **joints**;
4. Production of arrangement and drawings.

One of the undeterminable factors in design may be the loading itself. Dead load can be estimated quite accurately, but live loading, wind, impact, sway, and other **inertia** forces are extremely variable. Then there is the influence of temperature and the action of settling supports that often damage an otherwise well-designed structure. The engineering designer makes a **sincere** effort to evaluate the probable loads, but even his best judgment is unable to cope with the situation in all cases.

Designer over the years have attempted to achieve structural safety by ensuring that the effects of the applied loads on structures will not exceed the resistance or **capacity** of the structural members and connections, with a certain **margin** of safety. It may be expressed as

$$\text{Load effects } Q \leqslant \text{Resistance } R$$

This inequality is the basis for the design methods that have been continuously improved over many decades through research and development in materials, design procedures, analytical techniques, computer applications, erection and fabrication methods, structural performances and construction experience.

There are several methods in structural design. **Allowable Stress Design** (ASD), **Load and Resistance Factor Design** (LRFD) are within it. ASD method has been in use since before the 1900s. It is based on the assumption that the material behaves elastically, i.e. follows Hooke's law, under service load combinations. Certain **fractions** of the **yield stress** $f_y$ or the **ultimate strength** $f_u$ are used as allowable stresses for design purposes. The fractions usually are expressed in terms of factor of safety $F_s$.

The inequality Equation for ASD can be expressed as

$$\text{Load effects (stresses)} \leqslant \frac{\text{Yield Stress}}{F_s} \text{ or } \frac{\text{Ultimate Strength}}{F_s}$$

LRFD is a method of proportioning structural members using load and resistance factors, so no applicable limit state is reached when the structure is subjected to all appropriate load combinations. It is based on new developments in structural engineering. It incorporates the best of allowable or working stress design, strength design, load-factor design and plastic design, which are already familiar to designers.

LRFD is written in a form that prompts the designers to consider serviceability and strength limit states **systematically**, so a structure will have high performance throughout its 50 or more years of service life. High performance means few problems during low life-cycle cost.

In LRFD, each member and connection must satisfy the following equation for each limit state: $\Sigma \gamma_i Q_i \leqslant \Phi R_n$

Where $\gamma$= Load factor;

$Q$ = Load effect;

$\Phi$= Resistance factor;

$R_n$= **Nominal** resistance.

Different load factors are applied to different types of loads. For example, a smaller load factor is used for dead loads, because we can estimate these loads with better accuracy, while the load factor for live loads is larger, because of the uncertainties involved in determining the future changes in live loads. The connections are designed stronger than the members to reflect the lessons learned from structural performance and failures. This uniformity cannot be obtained with ASD using the same factor of safety for all types of loads, members, and **connections**.

## Words and Phrases

principle ['prinsəpl] *n.* 原理

capacity [kə'pæsiti] *n.* 承载力

yield stress 屈服应力

ultimate strength 极限强度

plastic design 塑性设计

margin ['mɑːdʒin] *n.* 安全系数，边界

fraction [ˈfrækʃən] *n.* 零头，小部分，系数
nominal [ˈnɔminl] *adj.* 标定的，名义上的
Allowable Stress Design 容许应力设计法
Load and Resistance Factor Design 荷载与抗力系数设计法
client [ˈklaiənt] *n.* 顾客，委托人
joint [dʒɔint] *n.* 接合，连接处
systematically [sistəˈmætikəli] *adv.* 系统地
inertia [iˈnə:ʃə] *n.* 惯性，惯量
sincere [sinˈsiə] *adj.* 实在的，真诚的
preliminary [priˈliminəri] *adj.* 初步的，预备的
specification [ˌspesifiˈkeiʃən] *n.* 说明书，规范
code [kəud] *n.* 章程，法规
elasticity [ilæsˈtisiti] *n.* 弹性
plastic hinge 塑性铰
connection [kəˈnekʃən] *n.* 连接，联系

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

Columns are vertical compression members of a structural frame intended to support the load-carrying beams. They transmit _______ from the upper floors to the lower levels and then to the ______ through the foundations. Since columns are ______ elements, ______of one in a critical location can cause the ______ collapse of the adjoining floors and the ultimate total collapse of the entire structure.

Ⅱ.Put the following into Chinese (English).

1. 弹塑性设计法
2. 应力应变曲线
3. 空间结构
4. 塑性和冲击韧性
5. 脆性破坏
6. coefficient of thermal expansion
7. double-layer grids
8. residual stress and distortion
9. yield strength and ultimate strength
10. chemical composition



# Section B Earthquake

**Earthquakes** are vibratory phenomena associated with shock loading on the earth's crust, while these shock loads can result from a number of causes, one of the primary reasons is the sudden **slippage** that frequently occurs between adjacent crust plates that make up the earth's surface.

Most earthquakes occur within the upper 15 miles of the earth's surface. Rut earthquakes can and do occur at all depths to about 450 miles. Their number decreases as the depth increase. At about 460 miles one earthquake occurs only every few years. Near the surface, earthquakes may run as high as 100 in a month, but the yearly average does not very much. In comparison with the total

number of earthquakes each year, the number of disastrous earthquakes is very small. Examples of such disastrous earthquakes are the 1999 **Izmir**, **Turkey** earthquake; the 1999 Jiji, Taiwan China Earthquake; the 1995 Henshin Japan Earthquake; the 1994 Northridge, California U. S. Earthquake; the 1976 Tangshan, China Earthquake; and many others.

China is one of the most seismically active regions in the world. There have been about 300 earthquakes with magnitudes greater than six in the continent of China since 1900 and seven of these have had magnitudes greater than eight. The largest earthquakes in China generally occur in one of five zones: 1) the Himalayan zone; 2) the central Asia zone, extending northeast from Pamir, through Altai in western Mongolia to Baikal; 3) the north-south zone, extending along the eastern margin of the Qinhai—Tibet Plateau; 4) the north China plain zone, which includes the Fenwei zone, the Hebei Plain and the Tanlu zone, along the Pacific Ocean.

The extent of the disaster in an earthquake depends on many **factors**. If you carefully build a toy house with an Erector set, it will still stand to matter how much you shake the table. But if you build a toy house with a pack of cards, a slight shake of the table will make it fall. An earthquake in **Agadir**, **Morocco**, was no strong enough to be recorded on distant instruments, but it completely destroyed the city. Many stronger earthquakes have done comparatively little damage. If a building is well constructed and build on solid ground, it will resist on earthquake. Most deaths in earthquakes have been due to faulty building construction or poor building sites. A third and very serious factor is **panic**. When people rush into narrow streets, more deaths will result.

The United Nations has played an important part in reducing the damage done by earthquakes. It has sent a team of experts to all countries know to be affected by earthquakes. Working with local geologists and engineers, the experts have studied the nature of ground and the type of most practical building code for the local area. If followed, these suggestions will make disastrous earthquakes almost a thing of the past.

There is one type of earthquake disasters that little can be done about. This is the disaster caused by **seismic** sea waves, or tsunamis. In certain area, earthquakes take place beneath the sea. These submarine earthquakes sometimes give rise to seismic sea waves. The waves are not noticeable out at sea because of their long wave length. But when they roll into harbors, they pile up into walls of water 6 to 60 feet high. The Japanese call them "**tsunamis**", meaning "harbor wave", because they reach a **sizable** height only in harbors.

Tsunamis travel fairly slowly, at speed up to 500 miles an hour. An earthquake warning system is in use to warn all shores likely to be reached by waves. But this only enables people to leave the threatened shores for higher ground. There is no way to stop the **oncoming** wave.

In spite of the great progress obtained in the field of earthquakes engineering during the past fifty years, recent destructive earthquakes occurred around the world revealed that the existing knowledge and techniques are still not sufficient to achieve safety against earthquakes at an effective cost. It is believed that among all natural hazards earthquakes are still number one disaster for which in-depth research, particularly for those devastating earthquakes, the basic research on earthquake engineering is still in need to expand our knowledge and strengthen our defenses.

In recognition of the recent rapid advancement of technologies related to earthquake engineering, high-speed development of satellite remote sensing technology has played significant

roles in reducing various kinds of natural disasters, it can be used in rapid assessing the seismic damage for effective post quake emergency action and in monitoring crustal movement for better understanding of seismic risk. **The Digital Disaster Reduction System** would be a specially designed system to study the virtual seismic damages that may happen to real structures during real earthquakes. It is a virtual reality computer system designed to simulate the occurrence and propagation of disaster and whole process of damages caused by natural disasters. The Digital Disaster Reduction System could be applied as a powerful tool not only for seismic disasters study but also for other natural disaster research.

## Words and Phrases

earthquake [ˈəːθkweik] *n.* 地震，大震动

factor [ˈfæktə] *n.* 因素，系数

panic [ˈpænik] *n.* 恐慌，惊慌

vibratory [ˈvaibrətəri] *adj.* (引起)振动的，震荡的

tsunami [tsjuːˈnɑːmi] *n.* 海啸，地震海浪

sizable [ˈsaizəbl] *adj.* 相当大的，广大的

oncoming [ˈɔnkʌmiŋ] *adj.* 即将来临的，接近的

Morocco [məˈrɔkəu] *n.* 摩洛哥

Agadir [ˌɑːgəˈdiə(r)] *n.* 阿佳迪尔(摩洛哥的一个水城)

slippage [ˈslipidʒ] *n.* 滑移，滑动

Izmir [izˈmiə] *n.* 伊兹密尔(土耳其的一个城市)

Turkey [ˈtəːki] *n.* 土耳其

the Digital Disaster Reduction System 数字减轻灾害系统

Himalayan [ˌhiməˈleiən] *adj.* 喜马拉雅的

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

In order to find the most ______ structural system under the given conditions, designers should be able to think in an ______ way, concentrating on the ______ between spatial forms and ______ systems, and ignoring trivial details. On the other hand, designers should also be able to distinguish the details which must be considered before the ______ of the whole system can be well understood.

Ⅱ.Translate the following passages from English into Chinese.

Within the last few years, research on building materials such as reinforced concrete and structural steel have made great strides and opened horizons for more efficient use of these materials. The structural engineers and architects also have met the challenge to find efficient and economical new structural systems for various ranges and heights of buildings going all the way to well over 100 stories.

## Section C Load Action and Propagation

Loads are forces acting on a structure. These loads are generated either directly by the forces of nature or by man himself. Their way through the structural system to the foundation is either vertical, such as dead, live, snow; or horizontal, such as earthquake, wind. A force has both magnitude and direction. The magnitude is specified by the value of the force, and direction is specified by the line of action and the sense of the force.

Loads can be classified into two categories: static and dynamic. Static loads are permanent and dynamic loads are always temporary. Dead loads may be defined as the static forces that are the weights of load-column, beam, floor, **partitioning wall**, **cladding wall**, etc. These loads are inside the building, other loads from inside the building are imposed by the live loads, such as people, library **bookshelves**, furniture, hospital beds, industrial equipment, etc. These loads are variable, and almost impossible to predict in static action. Their values take the form of statically equivalent loads. Loads from outside the building stem from the effects of natural environment on the building. These consist of snow, wind and earthquake loads. The snow loads acting on the roof cause the roof **deflect**, eventually collapse. Wind pressure values are given as functions of maximum annual mean wind velocities. The wind behavior and wind loading are studied through wind tunnel test. Because of the nature of wind and the lack of better information， wind loads are considered to be statically applied to the structure. Earthquake motions are applied at the base of building from the ground below and are considered to be random-type loading. The earthquake loads need not be considered if the building is not in earthquake zone. All these loads, whatever from inside or outside the building, depend largely on the location of the building, have to be taken by the structural system from all points and manners of application and transferred to the foundations.

It is clear that a proper **appreciation** of the behavior of a structural system, so essential to its proper design, requires a correct understanding of the mechanisms and methods of load propagation, such as tension, compression, bending, shear, and torsion, for simple systems and an additional elementary knowledge of at least deflections for somewhat more complex systems. Tension is one of the most elementary mechanisms and most efficient way by which load propagation takes place. In a **suspension bridge**, tension schemes generally require stiffening beams or trusses to avoid undesirable changes in **geometry** under moving or varying loads. Compression is the next most efficient method for carrying loads. The member must be designed to avoid **buckling**, either by making the member stocky or by adding supplementary **bracing**. Compression members weaken **drastically** when loads are not applied along the member axis, so moving, variable, and unbalanced loads must be carefully considered. Compression often exists in **column**. Through the mechanism of compression, the loads reach the foundation and hence the soil. In structural member, such as beam, when the loads act vertically to the **beam**, they are transmitted to the support by bending moment and shear force. The bending or flexure is resisted by one side of the member acting in tension while the other side acts in compression. Torsion is another of the methods by which load can be propagated toward the supports. Consider a tube subjected to a torque at the free end, the

tube is clamped at another end. Under the action of the torque, the tube twist, transferring the torque along its length until it reaches the support. Torsion creates a shear stress in material of the tube. This is because every section of the tube attempts to shear, in a circular manner across the force of every adjoining section.

In statics, the total moments, shears, and other **stresses** caused by a group of loads are equal to the sum of the separate loads if the materials are in the elastic stage. When the structure is in equilibrium, it must satisfy three conditions according to **the law of equilibrium**. (1) The sum of the horizontal forces must equal zero. (2) The sum of the vertical forces must equal zero. (3) The sum of the moments about three **rectangular coordinate** axes must equal zero. If the **resultant** force and moment were not zero, the structure would move under the action of the force and rotate under the action of the moment.

Although not all structural systems can be analyzed by the use of static alone, some can be solved easily. **Static determinacy** is not unique to the structural system, in general, the same structure can also be **statically indeterminate**. Understanding of load acting and propagation is important for an engineer to analyze structure，**verbalize** structural system, thereby design and construct structure.



## Words and Phrases

propagation [ˌprɔpəˈgeiʃən] *n.* 传递，传导，传播
partitioning wall 隔墙
cladding wall 填充墙
bookshelf [ˈbukʃelf] *n.* 书架
rectangular coordinate 直角坐标
verbalize [ˈvəːbəlaiz] *v.* 用词语表达
beam [biːm] *n.* 梁
column [ˈkɔləm] *n.* 柱
deflect [diˈflekt] *v.* 挠曲，下垂
stress [stres] *n.* 应力
statically indeterminate structure 超静定结构
static determinacy 静定
appreciation [əˌpriːʃieiʃən] *n.* 评价，鉴赏
the law of equilibrium 平衡原理
suspension bridge 悬索桥
geometry [dʒiˈɔmətri] *n.* 几何形状，几何学
buckling [ˈbʌkliŋ] *n.* 弯曲，屈曲，翘曲
bracing [ˈbreisiŋ] *n.* 撑杆，支撑
drastically [ˈdræstikəli] ad*v.* 彻底地，激烈地
resultant [riˈzʌltənt] *adj.* 合成的，总的

## Exercises

Ⅰ. Put the following into Chinese (English).

1. 平衡原理
2. 基础沉降
3. 风洞试验
4. 人口的平均密度
5. 地震和海啸
6. line of action and the sense of the force
7. load action and propagation mechanism
8. rectangular coordinate axes
9. dead loads and live loads
10. strength and stability criteria

Ⅱ.Decide whether the following statements are true (T) or false (F).

(　　) 1. In frame-shear system, the horizontal loads are resisted mainly by frame.

(　　) 2. If the height of tall building increases, the horizontal seismic action will decrease.

(　　) 3. In column, compression and tension are the most elementary mechanisms which load propagate.

(　　) 4. The extent of the disaster in an earthquake depends on faulty building construction, poor building sites and panic.

(　　) 5. Wind loads are dynamic, but they are often statically applied to the structure.




### 第 5 章　荷载和设计方法

Section A　结构设计原理

建筑师画建筑图以满足客户的需求。结构师检查不同的布置并进行初步设计以确定哪一个方案最经济。所有的结构设计都由规范控制，即使没有限制，设计师也很可能依靠一套标准的设计说明书作指导。所有的大城市都有建筑规范，这些规范不仅指定了工作应力，而且还有结构的其他特征。一套标准的技术规范代表了最实用的专业信息，设计时必须遵守当地建筑规范的技术说明。所有结构的设计都要能够承担荷载而不会有整体倒塌或构件破坏的危险。

已经证明，对设计师来说没有任何工具比弹性理论更有价值。由弹性理论给出的应力分布只能在结构的任何单元超过屈服点之前使用。一旦结构的任何部分开始屈服，应力分布就会改变。塑性设计方法完全依赖于塑性铰的形成，这要求材料有相当大的塑性。在塑性设计中，通过使用合适的安全系数，设计师可以按破坏荷载来设计普通的连续梁和框架，同时满怀信心地实现一个合理而平衡的设计。对于给定的布置，在结构设计中存在的问题是：

(1) 荷载的估计；
(2) 结构中应力和应变的确定；
(3) 构件和节点的设计；
(4) 布置和图纸的形成。

设计中的不确定因素之一可能就是荷载本身。静荷载可以估计得相当准确，但活荷载、风荷载、冲击荷载、摇摆和其他惯性力的变化非常大。温度的影响和柱的沉降常常会损害设计良好的结构。工程设计人员在估算可能的荷载方面做了实实在在的努力，但即使作了最佳

判断，也不能对所有的情形进行处理。

过去几年来，设计师尝试借助于某一安全系数，通过确保结构上施加的荷载效应不超过结构构件或连接的抵抗能力来获得结构的安全。这可以表示为

$$\text{荷载效应 } Q \leqslant \text{结构抗力 } R$$

这个不等式是设计的依据，在过去几十年通过对材料、设计方法、分析手段、计算机应用、建造和安装方法、结构性能和施工经验等的研究和发展不断得到改进。

在结构设计中有几种方法。容许应力设计法(ASD)，荷载与抗力系数设计法(LRFD)便包括在其中。ASD 法从 20 世纪 90 年代之前就在使用。它是基于材料为弹性的假定，即在使用荷载组合下符合胡克定律。将屈服应力 $f_y$ 或极限强度 $f_u$ 考虑某个系数作为容许应力进行设计。这些系数通常用安全系数 $F_s$ 来表示。

对于 ASD 法，不等式可以表示 $\text{荷载效应(应力)} \leqslant \dfrac{\text{屈服应力}}{F_s}$ 或 $\dfrac{\text{极限强度}}{F_s}$

LRFD 法是一种成比例的结构构件采用荷载和抗力系数的方法，因此结构在所有适当的荷载组合下不会达到极限状态。LRFD 法是以结构工程的最新研究为基础，它是容许或工作应力设计、强度设计、荷载系数设计及塑性设计的最好的综合，这些方法对设计师早已熟悉了。

LRFD 法可以以一种形式给出，它促使设计师系统地考虑正常使用和强度极限状态，因此，结构经过 50 年或更多年的使用期后仍性能良好。性能良好意味着较低的生命周期成本内出现的问题较少。

在 LRFD 法中，对于每个极限状态，每个构件和连接必须满足下面的等式：

$$\sum \gamma_i Q_i \leqslant \Phi R_n$$

式中，$\gamma$ 是荷载系数；$Q$ 是荷载效应；$\Phi$ 是抗力系数；$R_n$ 是标定的抗力。

不同的荷载类型采用不同的荷载系数。例如，对于恒载采用较小的荷载系数，因为我们能够较精确地估计出这些荷载，而对于活载采用较大的荷载系数，因为在确定活载将来的变化时存在不确定性。连接的设计强于构件以反映出从结构性能及破坏中学到的知识。这个统一性并不能够从 ASD 法中通过对所有类型的荷载、构件和连接采用相同的安全系数获得。

## Section B 地震

地震是一种与地壳上震动荷载有关的震动现象，这些震动荷载的产生有许多原因，主要的原因之一是构成地表的相邻板块之间突然的滑动。

大多数地震都是发生在地表 15 英里(1mile=1609.344m)范围内。但是地震也可以发生在 450 英里的深度。地震发生的数量随着深度的增加而降低。在大约 460 英里处，每几年才会发生一次地震。接近地表处，一个月内，地震可以高达 100 次，但是年平均次数并不多。与每年所有地震次数相比较，灾难性的地震次数非常少。损失惨重的地震如 1999 年土耳其伊兹密尔地震，1999 年中国台湾集集地震，1995 年日本神户地震，1994 年美国加利福尼亚北岭地震，1976 年中国唐山地震及许多其他地方的地震。

中国是世界上地震运动最活跃的地区之一。1900 年至今，中国大陆大约有 300 次震级超过六级的地震，其中有七次地震震级超过八级。中国最大的地震一般发生于五个地区之一：1)喜马拉雅山地区；2)中亚地区，从帕米尔地区向东北延伸，通过蒙古西部的阿尔泰山到贝加尔湖；3)南北地区，沿青藏高原的东边延伸；4)中国北部平原地区，包括环太平洋的汾渭地区、河北平原和郯庐地区。

地震中灾难的程度取决于许多因素。如果你用安装设备仔细地建一个玩具房子，无论你怎么摇晃桌子，它也不会倒塌，但是如果你用纸片建一个玩具房子，轻轻摇晃桌子它就会倒塌。摩洛哥阿佳迪尔的一次地震不够强，在远程仪器上没有记录下来，但是它完全破坏了这座城市。许多强震的破坏较小。如果建筑物建造得很好，基础坚实，它就能够抵抗地震。大多数地震中的人员死亡是由于建筑物建造错误或建筑物的位置不好。第三个因素也是最严重的因素就是恐慌，当人们冲向狭窄的街道时，就会导致更多的死亡。

英国在减小由地震产生的破坏方面起着重要的作用，英国把一支专家队伍送到了受地震影响的所有国家。专家们与当地的地质学家和工程师一起工作，研究了土壤的性质以及大多数当地实际采用的建筑规范类型。如果继续下去，这些建议将会使灾难性的地震几乎成为过去。

有一种类型的地震灾难人们能够做得很少，这就是由地震的海浪引起的灾难，或海啸。在某个区域，地震发生在海里，海里的地震有时会引起地震的海浪。这些浪由于波长较长在海里没有被注意到，但是当它们滚动到港湾时，就会堆积成 6～60ft 高的水墙。因为它们只在港湾处达到相当大的高度，所以日本人把它们称为“海啸”， 意思是“港湾波” 。

海啸推进的速度相当慢，为每小时 500mile。地震警告系统用于警告所有海浪可能到达的海港。但是这仅仅能够使人们离开受到威胁的海港到高一点的地面上，没有办法阻止即将来临的海浪。

尽管过去 50 年在地震工程领域取得了巨大进步，近来发生在世界范围的破坏性地震仍然表明现有知识和技术还不足以实现合理成本下的地震安全。我们相信在所有自然灾害中，地震仍然是需要深入研究的头号灾难，特别是那些破坏性地震，仍需要通过地震工程的基础研究扩充我们的知识并加强我们的防御能力。

近来与地震工程相关的技术得到快速发展。卫星遥感技术的快速发展对减轻各种自然灾害起到了重要作用，它可以用来快速评估地震损害以采取有效的震后应急行动，还可以用于检测地壳运动从而更好地了解地震风险。数字减轻灾害系统是一个专门为研究虚拟地震损害而设计的系统，这种虚拟的地震损害在真实的地震到来时可能发生在实际结构上。设计这个系统是为了模拟灾害的发生和传播以及由自然灾害引起的损害的整个过程。数字减轻灾害系统作为一个强有力的工具，不仅能够用于地震灾害的研究而且能够用于其他自然灾害的研究。



Section C　荷载作用和传递

荷载是作用在结构上的一些力，这些荷载可以是力直接作用，也可以是人为施加。它们通过结构体系作用于基础的方式可以是垂直的如恒载、活载、雪载；也可以是水平的，如地震荷载、风荷载。力有大小和方向。大小是通过力的值确定的，方向是由力的作用线和力的指向确定的。

荷载可以分为两类：静力荷载和动力荷载。静力荷载是永久的，动力荷载总是临时的。恒载是柱、梁、楼板、隔墙、填充墙等自重的静力荷载，这些荷载是来自建筑物的内部，来自建筑物内部的其他荷载是由活荷载施加的，如人、图书馆书架、家具、医院的床、工业设备等。这些荷载是变化的，以静态作用来预测它们几乎是不可能的，它们的值要采用静力等效的形式来确定。来自建筑物外部的荷载产生于建筑物上自然环境的影响。这些荷载包括：雪载、风荷载和地震荷载。雪载作用于屋面，引起屋面挠曲，甚至倒塌。风压力值按照每年平均风速最大值的作用给出。风的性能和风荷载是通过风洞试验研究的。由于风的性质以及缺乏较好的资料，风荷载都是按静力荷载施加到结构上的。作用于建筑物底部的地震力来自地面以下，它们是随机的荷载。如果建筑物不在地震区，就不需要考虑地震荷载。所有这些

荷载，不管是来自建筑物内部还是外部，极大地取决于建筑物的位置，这些荷载由结构体系从各个点以各种作用方式传递到基础。

很清楚，恰当评价一个结构体系的性能对于它的合理设计是极其重要的，这就需要正确理解荷载传递的机理和方法。例如对于简单的体系，应当了解拉伸、压缩、弯曲、剪切和扭转的知识；对于更复杂的体系，至少还应当知道关于挠度的基本知识。拉伸是荷载传递最基本的机理也是最有效的方法之一。在悬索桥中，受拉设计一般需要提高梁或桁架的刚度以避免在移动荷载或变化荷载作用下几何形状发生变化。压缩是另一个承担荷载最有效的方法之一，构件可以通过设计成短粗杆或增加辅助支撑以避免构件屈曲。当构件承受的荷载没有沿构件的轴线方向作用时，构件会急剧削弱，因此必须仔细考虑移动荷载、变化荷载及不平衡荷载。压缩经常存在于柱中，通过受压的机理，荷载能够到达基础从而到达土壤。在结构构件如梁中，当荷载垂直作用于梁上，它们由弯矩和剪力来传递。弯矩是由受拉一侧来抵抗的而另一侧是受压的。扭矩是荷载传递的另外一种方法，考虑一端固定，另一自由端承受扭矩的一根管子，在扭矩的作用下管子扭曲，并把扭矩沿着它的长度方向传递到支撑端，扭矩在管子材料里产生剪应力。这是由于管子的每个截面都试图在每个相邻截面之间沿圆周方向剪切。

在静力学中，如果材料处于弹性阶段，所有的弯矩、剪力以及由其他一组荷载引起的应力与这些荷载单独作用产生的应力之和相等。根据平衡原理，当结构处于平衡状态时，必须满足三个条件：(1)水平方向力的和必须为零；(2)垂直方向力的和必须为零；(3)关于三个直角坐标轴的力矩的和必须为零。如果合力和力矩和不为零，结构在力的作用下会发生移动，在力矩的作用下会发生转动。

尽管并非所有结构只使用静力学原理来分析，但是一些结构使用静力学原理还是很容易解决的。对于结构体系静定结构并不是唯一的，一般来讲，相同的结构也可以是超静定的。对于荷载作用及其传递的理解对于工程师分析结构，用词语表达结构体系从而进行结构的设计和施工是很重要的。

## Grammar：专业英语翻译技巧(II)——翻译的过程

## Translation Skills of English for Professional Purpose II—Translation Process

做好专业英语的翻译工作，要从以下三个方面入手。

(1) 理解。

做好翻译工作，首先要对原文理解，包括语言、语境及交际等方面的理解。没有对原文的准确理解是不够的。原文是翻译的基础和出发点。理解要尽量准确、全面，搞清楚词的意义和词的搭配关系，上下文的逻辑关系，把握语言的特点和风格，了解文化背景和社会进步对语言的影响。在此基础上才能深入理解，准确翻译。

**【例 1】** In order to develop our power industry, we must also lay stress on the development and construction of nuclear power station.

为了发展我国的电力工业，我们也必须注重研究并制造核电站。(“develop”译为“发展”，“development”译为“研究”)

其次在语境方面要从语言的内部入手，分析词或短语或句子的关系，确定它们的确切含义及潜在的意思表达。

【例 2】 Foundation are classified as “rigid” or “flexible”, depending on how they distribute loads.

按照传递荷载的情况，基础可分为“刚性的”或“柔性的”。(“rigid”译为“刚性的”)

(2) 表达。

表达阶段的任务就是译者根据其对原文的理解，使用汉语的语言形式恰如其分地表达原作的内容。在表达阶段最重要的是表达手段的选择，同一个句子的翻译可能有好几种不同的译法，但在质量上往往会有高低之分。

【例 3】 Action is equal to reaction, but it acts in a contrary direction.

译文一：作用相等于反作用，但它在相反的方向起作用。

译文二：作用与反作用相等，但作用的方向相反。

译文三：作用力和反作用力大小相等，方向相反。

译文一由于拘泥于原文结构，语言不够简练通顺；译文二虽然不错，但不如译文三；译文三完全摆脱了原文形式的束缚，并选用四字结构，使译文准确贴切，简洁有力。

(3) 校核。

理解和表达都不是一次完成的，往往是逐步深入，最后达到完全理解和准确表达原文的内容。因此，在翻译初稿完成之后，需反复仔细校对原文的译文，尽可能避免漏译、误译。

【例 4】 Theoretically, it may be used for either statically determinate or indeterminate structures, although for practical purposes the method limited to determinate structures because its use requires that the stress resultants be known the structure.

理论上，这个方法既可用于静定结构，又可用于非静定结构，但在实际应用中，它只限于静定结构，因为用这种方法时，要求知道整个结构的应力合力。

翻译时，既要分析句子的结构，又要考虑逻辑关系，同时要保证没有漏译或误译的现象。由此可见，校核对翻译而言也是非常重要的，尤其在专业英语翻译中，要求高度准确，其中的术语、公式、数字较多，稍有不慎就会造成谬误。

# Chapter 6

# Construction Engineering

## Section A Construction of Concrete Works

Extreme care is necessary for preparation, transport, plating and finish of concrete in construction works. It is important to note that only a bit of care and supervision make a great difference between good and bad concrete. The following factors may be kept in mind in concreting works.

### Mixing

The mixing of ingredients shall be done in a mixer as specified in the contract. The following sequence of charging the mixer may be adopted.

(1) Method of charging:

- Five to ten percent of the total quantity of water required for mixing, adequate to wet the drum thoroughly, shall be introduced before the other ingredients in order to percent any caking of cement on the blades or sides of the **mixer**.
- All dry ingredients shall be simultaneously rebonned into the mixer in such a manner that the period of flow for each ingredient is about the same. Eighty to ninety percent of the total quantity of water required for mixing shall be added uniformly with the dry ingredients.
- The remaining quantity of water shall be added after all the other ingredients are in the mixer.
- **Cobbles** or portion of the **coarse aggregate**, however may be added last.

(2) time of mixing:

The mixing time shall be followed as per the following:

| Capacity of Mixer | Minimum time of mixing | |
|---|---|---|
| | Natural Aggregate | Manufactured Aggregate |
| 3 cum. Or larger | 2 minutes | $2^{1}/_{2}$minutes |
| 2 cum | $1^{1}/_{2}$minutes | 2 minutes |
| 1 cum | $1^{1}/_{4}$minutes | $1^{1}/_{2}$minutes |

However for small mixer machine the time of mixing may be suitably adjusted for obtaining **homogeneous** mix.

## Handling and Conveying

The handling & conveying of concrete from the mixer to the place of final deposit shall be done as rapidly as practicable and without any objectionable separation or loss of ingredients. Whenever the length of haul from the mixing plant to the place of deposit is such that the concrete **unduly** compacts or segregates, suitable **agitators** shall be installed in the conveying system. Where concrete is being conveyed on **chutes** or on belts, the free fall or drop shall be limited to 5 ft.(or 150 cm.) unless otherwise permitted. The concrete shall be placed in position within 30 minutes of its removal from the mixer.

## Placing Concrete

No concrete shall be placed until the place of deposit has been thoroughly inspected and approved, all reinforcement, **inserts** and embedded metal properly security in position and checked, and forms thoroughly wetted (expect in freezing weather) or oiled. Placing shall be continued without avoidable interruption while the section is completed or satisfactory construction joint made.

**Within Forms** Concrete shall be **systematically** deposited in shallow layers and at such rate as to maintain, until the completion of the unit, a plastic surface approximately horizontal throughout. Each layer shall be thoroughly compacted before placing the succeeding layer. In general, the thickness of layers shall not exceed the following limits.:

(1) Vibrated mass concrete 45 cm.(or 18 in.)
(2) Hand compacted mass concrete 30 cm.(or 12 in.)
(3) Reinforced concrete 25 cm.(or 10 in.)

The batches shall be deposited vertically in such a manner as to avoid **segregation**, air pockets, or damage to other recently placed concrete. The concrete shall not be caused to flow or be worked along the forms for any distance, but shall be compacted as close to the point of deposit as practicable. Wherever necessary, both the forms and reinforcement shall be protected against splashing, and all accumulations of partially set, fried, or caked mortar which may impair the bond or show in the finished faces shall be removed and wasted before commencing concreting operations.



## Compacting

***Method.*** Concrete shall be thoroughly compacted by means of suitable tools during and immediately after depositing. The concrete shall be worked around all reinforcement, embedded fixtures, and into the comers of the forms. Every precaution shall be taken to keep the reinforcement and embedded metal in proper position and to prevent distortion.

***Vibrating.*** Wherever practicable, concrete shall be internally vibrated within the forms, or in the mass, in order to increase the plasticity as to compact effectively to improve the surface texture and appearance, and to facilitate placing of the concrete.

The intensity and duration of vibration shall be sufficient to cause complete settlement and compaction without any **stratification** of the successive layers or separation of ingredients. **Preliminary** experiments in vibrating shall be conducted under actual conditions of mix and placement in order to determine the **optimum** duration and method of vibration, as well as to

develop the necessary skill.

Vibration shall be continued the entire batch melts to a uniform appearance and the surface just starts to **glisten**. A minute film of **cement paste** shall be discernible between the concrete and the form and around the reinforcement. Over vibration causing segregation, unnecessary **bleeding** or formation of **laitance** shall be avoided.

## Curing and Protection

All concrete shall be protected against injury. Exposed finished surfaces of concrete shall be protected against heating and drying from the sun for at least 72 hours after placement. Concrete shall in general, be kept continuously (not periodically) moist for not less than 14 days. **Construction joints** shall be cured in the same way as other concrete and shall also, if practicable, be kept moist for at least 72 hours prior to the placing of additional concrete upon the joint. Horizontal and approximately horizontal surfaces shall be cured by sprinkling or by covering with damp sand, or by the use of wet sacks which satisfactorily retain the required amount of water for curing purposes. Where damp sand or sack cover is used for curing, it shall be completely removed later. Water curing shall be used on all concrete in dams and shall be applied by means of spray or sprinklers to cover the entire area of the concrete. Forms shall be kept sprinkled until removal. Concrete shall not be disturbed by workmen walking on it or by storing materials on the surface or otherwise for at least 10 hours after placing.

In special cases, such as powerhouses, the use of an approved, properly-applied sealing compound on limited areas shall be permitted. The **curing compound** shall be of the surface **membrane** type which shall thoroughly seal the concrete surface. Curing compound shall not be used on joints where bonding is required. The concrete surface shall be thoroughly wetted before applying the compound. All surfaces covered with curing compound shall be protected from traffic or injury of the sealing coat until expiration of the curing period. All methods used for curing shall leave the concrete free from any **discolouration** or damage to the concrete.

## Words and Phrases

mixer [ˈmiksə] *n.* 搅拌机，搅拌器
cobble [ˈkɔbl] *n.* 鹅卵石；中砾；圆石
coarse aggregate 粗集料，粗骨料
homogeneous [ˌhɔməuˈdʒiːnjəs] *adj.* 同种的，同类的，相似的；纯一的，均质的；均匀的
unduly [ˌʌnˈdjuːli] *adv.* 不适当地，过度地
agitator [ˈædʒiteitə] *n.* 搅拌器，搅拌机，搅拌装置
chute [ˈʃuːt] *n.* 斜槽；滑槽；险陡滑道
insert [inˈsəːt] *n.* 插入物；*vt.*插入
systematically [sistəˈmætikəli] *adv.* 系统地，有系统地，有组织地，有条理地
segregation [ˌsegriˈgeiʃən] *n.* 隔离，分离，离析偏析，被隔离的部分
stratification [ˌstrætifiˈkeiʃən] *n.* 层化，阶层的形成，成层，分层
preliminary [priˈliminəri] *adj.* 初步[级，始]的，预备的，在前的
optimum [ˈɔptiməm] *n.* 最适条件，最佳效果，最优值；*adj.* 最优的，最适宜的

glisten [glisn] *vi.* 闪亮，辉耀；*n.*闪光，闪耀
cement paste 水泥浆
bleeding ['bli:diŋ] *n.* (沥青路面)泛油；(水泥混凝土表面)泛浆；凝胶收缩；渗色
laitance ['leitəns] *n.* 水泥翻沫；浮浆皮；水泥乳；浮浆
joint [dʒɔint] *n.* 接合；榫；粘接处；铰链；接头；接缝；分型面；(木模)接榫
construction joint 施工缝
curing compound 养护剂
membrane ['membrein] *n.* (薄)膜，隔膜；表层
discolouration [diskʌlə'reiʃən] *n.* 变[褪，脱]色，漂白；染污，斑渍，污点

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. It is important ________ note that only a bit of care and supervision make a ________ difference ________ good and bad concrete.

2. The handling＆conveying ________ concrete ________ the mixer ________ the place ________ final deposit shall be done as rapidly as practicable and________any objectionable separation or loss of ingredients.

3. The batches shall be ________ vertically in such a manner as to avoid ________, ________, or damage to other recently ________ concrete.

Ⅱ. Translate the following passages from English into Chinese.

The concrete production is composed by many connected parts including the aggregate quarry, batching plants, delivery truckmixers, concrete pumps and so on. Every part involve concrete works likes a group of rings connected with each other. In case any ring goes wrong in trouble it with affect all concrete works. So the coordination for concrete works is very important.

Other problems are the selection of electrical and mechanical equipment and the design of structural features for concrete material processing and mixing plants and for compressed air, water, and electrical distribution systems.



# Section B Construction Equipment

## Introduction

The activities involved in construction projects where the magnitude of the work is on a large scale, speedy work and timely completion of work with quality control are very vital. In order to achieve this, mechanization of work has to be done, where construction machinery & equipment play a pivotal role. The need for mechanization arises due to the following reasons:

- Magnitude & complexity of the project.
- Projects involving large quantities of material handling.
- Complexity of projects using high grade materials.
- High quality standards.

- Importance of keeping the time schedules.
- Optimum use of material, manpower and finance.
- Shortage of skilled and efficient manpower.

Proper use of appropriate equipment contributes to economy, quality, safety, speed and timely completion of the project. Construction equipment is an important part of any construction process. It is not always desirable or possible for the contractor to own each and every type of construction equipment required for the project. Considering the various aspects of the utility of particular equipment, the contractor has to economically justify whether to purchase the equipment or to hire it. The amount invested in the purchase of equipment should be recovered during the useful period of such equipment.

## Equipment Selection

One of the most important tasks in the pre-construction planing process is equipment selection. There are many variables to consider when selecting equipment. Following factors should be considered at the time of selecting construction equipment:

- The equipment should be standard equipment if possible.
- It should give the best service at low cost.
- Its unit cost of production should be moderate.
- It should be easily repairable with low **shutdown period.**
- It should be easily disposed off.
- It should suit the majority of the requirements of the job.
- It should be capable of doing more than one function.
- It should be of moderate size, as they have fewer moving parts and have low working cost.

Considering the above, one can either purchase or hire the equipment. If the equipment is to be used frequently and for a long duration of time on the project, it proves to be economical to purchase the equipment. On the contrary, if the equipment is to be used occasionally and for a short duration of time on the project, it proves to be economical to get it hired.



## Type of Construction Equipments

It is customary to classify construction machines in accordance with their functions such as **hoisting**, **excavating**, **hauling**, **grading**, **paving**, **drilling**, or pile driving. There have been few changes for many years in the basic types of machines available for specific jobs, and few in the basic **configurations** of those that have long been available. Design emphasis for new machines is on modifications that increase speed, efficiency, and accuracy (particularly through more sophisticated controls); that improve operator comfort and safety; and that protect the public through **sound attenuation** and emission control. The selection of a machine for a specific job is mainly a question of economics and depends primarily on the ability of the machine to complete the job efficiently, and secondarily on its availability.

***Earth-moving machines.*** The equipment used in heavy construction, especially civil engineering projects, which often require the moving of millions of cubic meters of earth. The removal of earth or material from the bottoms of bodies of water is performed by dredges.

The primary earth-moving machine is the **heavy-duty tractor**, which, when fitted with **endless tracks** to grip the ground and with a large, movable **blade** attached in front, is called a **bulldozer**. Bulldozers are used to clear brush or **debris**, remove **boulders**, and level ground. A **scraper** is a machine that may be pulled by a tractor or may be self-powered. It consists of a blade and a box or container. Dirt is scraped by the blade into the container; the dirt may then be released so as to form an even layer of a predetermined thickness, or be carried off for disposal elsewhere. Scrapers are used to level land, as in road construction.

Somewhat similar to scrapers are **graders**, self-propelled, wheeled machines with a long, inclined, vertically adjustable steel blade. Graders are primarily **finishing equipment**; they level earth already moved into position by bulldozers and scrapers. Lightweight tractors fitted with wheels in place of tracks are used for comparatively light construction jobs. Equipped with a **backhoe**, which is an open **scoop** attached rigidly to a hinged **boom**, such a vehicle can dig shallow trenches; equipped with a **front-end** loader, a scoop shovel affixed to the front of the tractor, it can lift and carry gravel, stone, sand, and other construction materials.

**Draglines** and power **shovels** are the primary forms of excavation equipment. A dragline is fitted with an open scoop supported from the end of a long boom by a wire cable. The scoop is dragged along the ground by the cable until it is filled with earth, which is then dumped elsewhere. Draglines are used primarily to excavate deep holes. Power shovels are fitted with **buckets** called **clamshells**, which dig into the earth and shovel it up. The bottom of the clamshell opens to dump the dirt into a truck for removal.

***Hoisting equipment.*** This class of equipment is used to raise or lower materials from one elevation to another or to move them from one point to another over an **obstruction**. The main types of hoisting equipment are **derricks**, **cableways**, cranes, elevators, and **conveyors**.

Mechanisms for raising and lowering material with intermittent motion while holding the material freely suspended. Hoisting machines are capable of picking up loads at one location and depositing them at another anywhere within a limited area. In contrast, elevating machines move their loads only in a fixed vertical path, and **monorails** operate on a fixed horizontal path rather than over a limited area.

The principal components of hoisting machines are: **sheaves** and **pulleys**, for the hoisting mechanisms; **winches** and **hoists**, for the power units; and derricks and cranes, for the structural elements.

Sheaves and pulleys or blocks are a means of applying power through a rope, wire, cable, or chain. Sheaves are wheels with a **grooved periphery** that change the direction or the point of application of a force transmitted by means of a rope or cable. Pulleys are made up of one or more sheaves **mounted** in a frame, usually with an attaching swivel hook, eye, or similar device at one or both ends. Pulley systems are a combination of blocks.

Normally, winches are designed for stationary service, while hoists are mounted so that they can be moved about, for example, on wheel **trolleys** in connection with overhead crane operations. A winch is basically a drum or cylinder around which **cordage** is coiled for hoisting or hauling. The drum may be operated either manually or by power, using a **worm gear** and **worm wheel**, or a **spur gear** arrangement. A **ratchet** and **pawl** prevent the load from slipping; large winches are equipped with brakes, usually of the external band type.

A derrick is distinguished by a **mast** in the form of a slanting boom **pivoted** at its lower end and carrying load-supporting **tackle** at its outer end. In contrast, **jib cranes** always have horizontal booms. Derricks are standard equipment on construction jobs; they are also used on freighters for loading and unloading cargo, and on barges for dredging operations. Hoisting machines with a bridgelike structure spanning the area over which they operate are **overhead-traveling** or **gantry cranes**.

## Words and Phrases

shutdown period 停工期(时间)
hoist [hɔist] *n.* 绞车
hoisting ['hɔistiŋ] *n.* 起重；*adj.*提升
excavating [ekskə'veitiŋ] *n.* 挖掘，挖取
hauling [hɔ:liŋ] *n.* 搬运，运输
grading ['greidiŋ] *n.* 等级，分阶段，坡度缓和
paving ['peiviŋ] *n.* 铺面，铺砌
drilling ['driliŋ] *n.* 演练，钻孔
configuration [kən,figju'reiʃən] *n.* 结构，布局，形态；[计算机]配置
sound attenuation 消音，消声，声衰减
tractor ['træktə] *n.* 拖拉机
heavy-duty tractor 重型拖拉机
endless ['endlis] *adj.* 无止境的，没完没了的
track [træk] *n.* 小路，跑道，轨道，踪迹；惯例，常规；*vt.* &*vi.* 跟踪，追踪
blade [bleid] *n.* 刀锋，刀口
bulldozer ['buldəuzə] *n.* 推土机
debris [də'bri:] *n.* 碎片，残骸
boulder ['bəuldə] *n.* 大圆石
scraper ['skreipə] *n.* 铲运机
grader ['greidə] *n.* 平地机
finishing equipment 精整设备
backhoe ['bækhəʊ] *n.* 反向铲
scoop [sku:p] *n.* 铲子，舀取，独家新闻；*v.* 汲取，舀取，抢先登出
boom [bu:m] *n.* 繁荣，隆隆声；*v.* 急速发展
front-end 前端
dragline ['dræglain] *n.* 拉索(拉铲挖土机，绳斗电铲，挖掘斗)
shovel ['ʃʌvl] *n.* 铲(挖斗机，一铲的量)；*vt* 铲(挖，舀)
bucket ['bʌkit] *n.* 水桶
clamshell ['klæmʃəl] *n.* 蛤壳(抓斗，蛤壳式挖泥机)
obstruction [əb'strʌkʃən] *n.* 障碍，妨碍，闭塞
derrick ['derik] *n.* 动臂起重机(油井架吊杆，进线架，飞机的起飞塔)
cableway ['keiblwei] *n.* 空中索道
conveyor [kən'veiə] *n.* 输送机(运送者，交付者)
monorail ['mɔnəureil] *n.* 单轨铁路

sheaves [ʃi:vz] *n.* 滑轮
pulley ['puli] *n.* 滑车
winch [wintʃ] *n.* 卷扬机
blocks ['blɔks] *n.* 吊链，滑轮组
grooved [gru:vd] *adj.* 开槽的
periphery [pə'rifəri] *n.* 表面周围外围
mounted ['mauntid] *adj.* 安装好的
eye [ai] *n.* 吊环
trolley ['trɔli] *n.* 缆车
cordage ['kɔ:didʒ] *n.* 缆索(绳索，木材总数)
worm gear 蜗轮传动装置
worm wheel 蜗轮
spur gear [机]正齿轮
ratchet ['rætʃit] *n.* 棘齿，单向齿轮
pawl [pɔ:l] *n.* 倒齿，制动爪
mast [mɑ:st] *n.* 桅杆
slanting ['slɑ:ntiŋ] *adj.* 倾斜的
pivoted ['pivətid] *adj.* 转动的回转的
tackle ['tækl] *n.* 工具，复滑车，扭倒；*v.* 处理,抓住
jib [dʒib] *n.* 船首三角帆，铁臂；*v.*移转，踌躇不前，停止不动
jib crane 回转起重机，臂架起重机
overhead-traveling crane 桥式起重机
gantry ['gæntri] *n.* 起重机架(台架，导弹拖车，雷达天线)
gantry crane 龙门起重机

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The amount invested ________ the purchase ________ equipment should be recovered ________ the useful period ________ such equipment.

2. The principal components of hoisting machines are: ________ and ________, for the hoisting mechanisms; ________ and ________, for the power units; and ________ and ________, for the structural elements.

3. Normally, ________ are designed for stationary service, while ________ are mounted so that they can be moved about, for example, on wheel ________ in connection with overhead ________ operations.

Ⅱ. Translate the following passages from English into Chinese.

A scraper may be self-propelled or pulled by a tractor. It has a knifelike cutter that planes off a layer of soil into an internal reservoir that can hold up to 1,400 cubic feet (40 cubic meters) hydraulic rams and the machine can transport its load to a nearby site, where it is dumped.

A bridge crane has a box-girder beam (called a gantry) running on long elevated tracks an each

of its ends. The gantry can move backward and forward along the tracks. The hoisting system is carried in a trolley, which moves along the gantry beam. Bridge cranes are commonly set up above a working area to handle such loads as tree trunks and steel beams.



## Section C Scaffolding

### Introduction

**Scaffolding** is a temporary **framework** around or even inside a building to support construction and repair of buildings and structures. Scaffolding is one of the major requirements in any construction field. May it be large structures or smaller homes, scaffolding is an essential part. In Britain and most of the European nations, scaffolding is done with pipes whereas in Asian countries bamboo is used still.

Scaffolding consists of 3 main parts, tubes, **couplers** for joining the tubes and boards, to create a supporting area for human access. Scaffoldings are seldom alone, they are always attached to the building with **ties**. Other common materials include base plates, ladders, ropes, anchor ties, reveal ties, **gin** wheels, **sheeting**, etc. Independent scaffoldings are seldom seen and are usually not as stable as the ones attached to a structure.

Tubes are made of steel or aluminum. Steel is usually **galvanized**. The aluminum tubes render more durable as its light and flexible. Boards are made of **seasoned** wood and should be 50 mm-63 mm to meet the standards.

### Scaffold Safety

Since scaffolding is a spot designed structure, it is possible to go in and come out of scaffolding. Keeping in view the flexibility of the requirement the scaffold factory's produce accordingly.

Good foundations are very essential. Scaffolding can be used without base plates on concrete or similar hard surfaces, although base plates are essential. A working platform requires certain other elements to be safe. They must be close-boarded, have double **guard rails** and toe and stop boards. Safe and secure access must also be provided. Scaffolds are independent structures. To provide stability tie holds are generally tied to the **adjacent** building or to any solid immovable structure.

Rules are regulations vary in every part of the world when it comes to construction. In certain parts of the world there exists rules for building scaffolding and **norms** and standards are practiced strictly. Britain has a strict code of conduct too and all scaffoldings are expected to meet certain standards based on Provision and Use of Work Equipment Regulations.



### Types of Scaffolds

There are a few types of scaffold: independent or bridge scaffold, single pole scaffold, suspended scaffold, **cantilever** scaffold and hanging bracket scaffold. Some commen scaffolds are as follows:

***Tube and coupler.*** Tube and coupler scaffolds are so-named because they are built from tubing connected by coupling devices(Fig. 6.1). Due to their strength, they are frequently used where

heavy loads need to be carried, or where multiple platforms must reach several stories high. Their **versatility**, which enables them to be assembled in multiple directions in a variety of settings, also makes them hard to build correctly.

***Frame or fabricated.*** Fabricated frame scaffolds are the most common type of scaffold because they are **versatile**, economical, and easy to use. They are frequently used in one or two tiers by residential contractors, painters, etc., but their modular frames can also be stacked several stories high for use on large-scale construction jobs(Fig. 6.2).

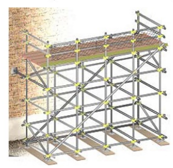


Fig. 6.1 Tube and coupled

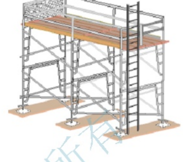


Fig. 6.2 Frame scaffolds

***Pump jack.*** Pump jacks are a uniquely designed scaffold consisting of a platform supported by moveable brackets on vertical poles. The brackets are designed to be raised and lowered in a manner similar to an automobile jack(Fig. 6.3). Pump jacks are appealing for certain applications because they are easily adjusted to variable heights, and are relatively inexpensive.

***Mobile.*** Mobile scaffolds are a type of supported scaffold set on wheels or **casters**(Fig. 6.4). They are designed to be easily moved and are commonly used for things like painting and plastering, where workers must frequently change position.





Fig. 6.3 Pump jack Fig



Fig.6.4 Mobile scaffolds

***Swing stage.*** Swing scaffolds are suspended by means of wire ropes or chains and are not provided with a means of being raised or lowered by a lifting appliance. Their main use is for gaining access to high ceilings or the underside of high roofs. A secure **anchorage** must be provided for the suspension ropes, and this can usually be achieved by using the structural members of the roof over the proposed working area. Any member selected to provide the anchorged point must be inspected to assess its adequacy. At least six evenly spaced suspension wire ropes or chains should be used, and these must be adequately secured at both ends. The working platform is

constructed in a similar manner to conventional scaffolds, consisting of **ledgers**, **transoms** and timber scaffold boards with the necessary guard rails and toe boards. Working platforms in excess of 2.4m×2.4m plan size should be checked to ensure that the supporting **tubular** components are not being overstressed.

## Hazards associated with scaffolding

As there are advantages like economy and ease in construction, there are some hazards associated with scaffolds.

An estimated 65% of the construction industry, or 2.3 million workers, regularly use scaffolding so employees can reach difficult-to-reach areas of buildings. Around 50 people die each year in the UK because of scaffolds that have collapsed and over 4500 are injured due to faulty or defective scaffold. Therefore, it should not be surprising that some of the most common accidents on worksites involve injuries incurred on or related to scaffolds.

The main accidents that lead to an injury are:

- Falls from elevation, due to lack of fall protection;
- Collapse of the scaffold, caused by instability or overloading;
- Being struck by falling tools, work materials, or **debris**; and
- **Electrocution**, principally due to **proximity** of the scaffold to overhead power lines.

To insure safety, a scaffold should always be assembled in accordance with the designer's instructions and the scaffold plan. Any person doing scaffolding work more than twelve feet (about 3.7 meters) above ground must hold a training and competency certificate. The scaffoldings come with requisite belts, ropes and other accessories enabling fastening. The regular monitoring and routine check of these frames cannot be neglected. In most countries, there will be random checks conducted on the scaffolding on industrial construction sites to ensure that they meet all their safety regulation requirements.

## Words and Phrases

scaffold [ˈskæfəld] *n.* 鹰架，脚手架
scaffolding [ˈskæfəldiŋ] *n.* 脚手架(搭脚手架)
framework [ˈfreimwəːk] *n.* 结构，构架，框架
gin [dʒin] *n.* 杜松子酒；*v.* 开始
gin wheel 起重滑轮
sheeting [ˈʃiːtiŋ] *n.* 薄片(薄膜，帐篷，挡板，极板，护提板，护墙板，板栅)
galvanized [ˈgælvənaizd] *v.* 电镀(刺激)；*adj.* 镀锌的
guard rail 护栏
seasoned [ˈsiːznd] *adj.* 经验丰富的
adjacent [əˈdʒeisənt] *adj.* 毗连的，邻近的，接近的
norm [nɔːm] *n.* 标准，规范
coupler [ˈkʌplə] *n.* 耦合器
versatility [ˌvəːsəˈtiləti] *n.* 多才多艺，用途广泛，万能
jack [dʒæk] *n.* 插座，千斤顶；*v.*抬起，提醒，扛举

caster ['kɑːstə] *n.* 脚轮；投手，投掷者；铸造者
stage [steidʒ]台架，脚手架
anchorage ['æŋkəridʒ] *n.* 下锚，停泊所，停泊税
ledger ['ledʒə] *n.* 账簿
transom ['trænsəm] *n.* 横档，横楣，横梁
tubular ['tjuːbjulə] *adj.* 管状的
debris ['debriz] *n.* 碎片，残骸
electrocution [iˌlektrə'kjuːʃən] *n.* 电死(人或动物)，以电刑处死，触电死

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Due to their strength, they are frequently used ________ heavy loads need to be carried, or ________ multiple platforms must reach several stories high.

2. Fabricated frame scaffolds are the most common type of scaffold because they are ________, economical, and easy to use. They are frequently used in one or two ________ by residential contractors, painters, etc., but their modular ________ can also be ________ several stories high for use on large-scale construction jobs.

3. In most countries, there will be random checks conducted ________ the scaffolding ________ industrial construction sites to ensure that they meet all their safety regulation requirements.

Ⅱ.Translate the following passages from English to Chinese.

Scaffolds shall only be erected and disassembled by competent approved and qualified personnel. Proper provisions must be made for the safe lifting of scaffold fittings, poles and boards. Lifting equipment must be designed to prevent the possibility of scaffold falling to grade in the event that the load snags or knots slip. Throwing and dropping equipment is strictly prohibited.

Scaffolds must be erected on sound surfaces and base plates must be used at all times. Footing or anchorage for scaffolds shall be rigid, and capable of carrying the maximum intended load without settling or displacement. Unstable objects such as barrels, boxes, loose brick or concrete blocks shall not be used to support scaffolds.



# 参 考 译 文

## 第6章 建 筑 施 工

Section A 混凝土工程施工

施工过程中必需要特别注意混凝土的准备、运输、浇筑及浇筑完成等工作。稍许的留意和监督就会使混凝土质量的好坏产生很大的差异，注意到这一点很重要。混凝土施工中，以下因素应当谨记。

**搅拌**

各组成材料应当按合同中的规定在搅拌机中搅拌。应当参照以下搅拌机装料顺序。

(1) 装料方法

- 在其他组成材料加入之前，用总的搅拌用水量的5%～10%，充分浸湿滚筒，可以降低搅拌叶片和滚筒内壁的粘灰率。
- 80%～90%的总用水量要与干料均匀地拌合。
- 剩下的水要在所有其他组成材料全部进入搅拌机后加入。
- 而卵石或部分粗骨料可以最后加入。

(2) 搅拌时间

搅拌时间应当遵循以下要求：

| 搅拌机容量 | 搅拌最少时间 | |
|---|---|---|
| | 天然材料 | 加工材料 |
| ≥3m$^3$ | 2min | 2.5min |
| 2m$^3$ | 1.5min | 2min |
| 1m$^3$ | 1.25min | 1.5min |

不过，为了能够搅拌均匀，对于小型搅拌机的搅拌时间可以适当调整。

**装卸输送混凝土**

混凝土从搅拌机到最终浇筑位置间的装卸运输应当既快又好地完成，不发生离析或成分损失。无论什么时候，从搅拌设备到浇筑地点之间的距离，不应使混凝土变稠或离析，运输系统中要安装合适的搅拌器。混凝土应通过斜槽或输送带进行传送，除非允许，否则自由下落高度应当控制在5 ft(或150 cm)。混凝土应当在30 min内从搅拌机运送到浇筑地点。

**浇筑混凝土**

浇筑混凝土之前，浇筑地点必须经过完全的检查并经允许，所有钢筋、预埋件及内置金属恰当可靠地安装到位并经检查合格，模板完全浸湿(冰雪天气除外) 或上油。浇筑混凝土应当无间断地连续进行，浇筑部分完整，或接缝可靠。

**入模**　混凝土应当有条理地按薄层浇筑，并保持这种的速度，直到浇筑完整个单元，整个单元的塑性表面大致水平。每一层混凝土应当在后一层浇筑前进行压实。通常，每一层的厚度不应当超过以下控制：

(1) 振动混凝土；　45 cm(或 18 ft)

(2) 人工压实混凝土；　30 cm(或 12 ft)

(3) 钢筋混凝土。　25 cm (或 10 ft)

整批混凝土应当垂直地浇筑，避免产生离析、气泡，或对新近浇筑的混凝土产生破坏。应避免使浇筑的混凝土在模板中随意流动(或人为移动)，尽可能地使其在浇筑位置处压实。施工过程中，要避免模板和钢筋的溅污，浇筑前，模板内囤积的凝浆、干浆、砂浆块等杂物应清除干净，否则浇筑混凝土的黏结强度和表观都会受到影响。

**密实**

**方法**　混凝土在浇筑期间或浇筑后立即使用合适的工具进行密实。混凝土应包裹钢筋及内置夹具，填满模板空间。要采取措施保证钢筋和预埋金属的准确位置，防止变形。

**振捣**　浇筑过程中，混凝土应当在模板内进行内部振捣，以此来增加可塑性，使其充分密实从而改善表面组织及观感，还便于混凝土的浇筑。

混凝土的振捣程度及振捣时间应当足以使其完全下沉和密实，不发生任何的连续层分层或成分的离析。应当在实际拌合与浇筑的条件下进行初步的振捣试验，以确定振捣的最佳时

间和振捣方法，还可改进必要的技能。

振捣应持续到整批混凝土完全混合，外观均匀且表面开始泛光。在混凝土与模板间以及钢筋周围，可以看出一薄层水泥浆膜。过度的振捣会引起离析、不必要的泌水，或生成浮浆，应当避免。

**养护与成品保护**

应当保护全部混凝土，防止损伤。暴露在空气中的混凝土成品表面至少应当在浇筑完成后 72 h 内采取保护措施，防止由于太阳照射引起的受热和干燥。通常，混凝土应当持续(非阶段性)保持潮湿，不少于 14 天。同其他混凝土一样，施工缝应当以同样的方法进行养护，如果有可能，在浇筑施工缝另外部分混凝土前，至少也应该保持潮湿状态 72 h。水平或近似水平的混凝土表面，是通过洒水或覆盖湿砂进行养护的，或利用含有所需数量水的湿布袋进行养护。养护用的湿砂或布袋覆盖层最后要全部取走。水养护用于所有大坝混凝土，通过喷雾器或洒水车来覆盖混凝土全部表面。至少在浇筑完 10 h 后，工人才可以在上面走动，表面才可堆放材料。

在一些特殊情况下，如发电厂的混凝土施工，在一定范围内适当使用经过许可的密封剂是可以的。表层膜式的养护剂将完全密封混凝土表面。需要结合的施工缝处不得使用养护剂。在使用养护剂之前混凝土表面要完全湿润。要保护涂有养护剂的混凝土表面，防止在养护期期满之前通行或密封层受损。所有养护方法都将使混凝土免遭污染和破坏。

## Section B 施工设备

**简介**

大型施工项目的施工能够在满足质量要求条件下快速、按时完成是非常重要的。为达到此要求，必须要使用机械设备，施工机械及设备在这种场合下发挥非常重要的作用。对施工机械需求的不断增长主要取决于以下因素：

- 项目的规模大小及复杂程度；
- 大量建筑材料的装运；
- 使用高级材料项目的复杂程度；
- 高质量标准；
- 保证工期的重要程度；
- 最佳使用材料、人员及资金情况；
- 缺少技术好、劳动效率高的工作人员。

恰当使用合适的设备有益于项目经济、保质、安全、较快地按时完成。施工设备在建造过程中是重要的组成部分。通常不要求承包方自己拥有各种项目所需要的施工设备，考虑到特殊设备实用性等诸多方面，承包商必须要从经济角度考虑，是购买该设备还是租赁。确定投资购买设备的数量时应当考虑这种设备在使用期内能否收回成本。

**设备选择**

在施工准备阶段，设备的选择是最重要的任务之一。考虑什么时候选择设备有许多因素。在选择设备时应当考虑以下因素：

- 设备应当尽可能是标准设备；
- 该设备应当以较低的成本提供最好的服务；
- 产品的单位成本应当适中；
- 容易修理且停机时间短；

◆ 应当容易处理掉；
◆ 性能应当符合大部分施工作业的要求；
◆ 具有多功能；
◆ 由于移动部分较少、工作成本较低，设备尺寸应当适中。

针对以上因素，人们选择购买或者是租赁设备。如果某设备经常使用，或者是在项目中使用较长时间，则购买设备证明比较经济。相反，如果设备偶尔使用，或在项目中使用时间很短，则租赁设备变得比较经济。

**施工机械的种类**

通常施工机械按照其功能进行分类，如提升、挖掘、搬运、平整、铺路、钻孔，或打桩。多年来，用于特定工作的机械的基本种类以及那些使用了很长时间机械的配置基本没有变化。对于新型施工机械的设计，则强调在速度、效率以及精确度(尤其通过先进技术控制)上加以改进，并且在改善操作人员舒适度和安全性，以及消音和排放控制等保护公众健康方面也要加以改进。为某项具体工作而选择机械是经济学问题，首先取决于有效完成工作的机械设备的能力，其次取决于该设备的可利用性。

**土方机械** 大型工程中尤其是那些需要经常移动数百万方土方的土木工程施工项目中使用的一种设备，从水底挖土或其他材料，需要由挖泥船来完成。

主要的挖土机械是重型拖拉机，当其装备夹紧地面的环状履带，前部安装可移动的铲刀时，就成了推土机。推土机是用来清理碎屑、移动砾石和平整地面的。铲运机是一种由拖拉机牵引或自行牵引的机械，由铲刀和盛料斗组成。铲刀将泥土铲入盛料斗，然后运到指定位置卸下，以便形成预定厚度的垫层，或是运走处理掉。铲运机用来平整场地，在道路工程中也有同样的应用。

与铲运机有些类似的是平地机，一种装有长而倾斜的、垂直方向可调整的钢制铲刀。平地机是主要的精整设备，平整已经经过推土机和铲土机施工过场地。履带位置处装有轮胎的轻型拖拉机，用于规模较小的施工任务。反铲是一种与铰链吊臂附着坚固的后铲，这种机械能够开挖浅沟；前端转载机是一种推土机前端装有铲斗的机械，它能够举起和运输碎石、石头、沙子和其他施工材料。

拉铲挖土机和动力挖掘机是主要形式的土方机械。拉铲挖土机装有通过长悬臂端部所连接缆绳固定的料斗。料斗沿着地面由缆绳牵引直到装满了土，再将这些土倒掉。拉铲挖土机主要用于开挖深坑。动力挖掘机装有称为抓斗的铲斗，该铲斗掘进土中，并将土挖掉。

**起重设备** 这种设备用于从一个高度向另一个高度提升或降低材料的高度，或越过障碍从一处向另一处转移材料。提升设备的主要类型有桅杆式起重机、缆索起重机、吊车、升降机，以及传送带。

操纵重物在空中升降的机械装置。起重机能够在有限的范围内将重物从一处提起，堆积到另一处。相反，升降机只能沿一段固定的垂直路线移动重物，而单轨索道只能在某一固定的线路上运送重物(并非像起重机那样可以在一个有限的范围内进行随意操纵重物)。

起重机械主要组成为：起重装置是滑轮和滑车，动力装置是卷扬机和绞车，结构部分是起重机和吊车。

滑轮、滑车或吊链通过绳子、钢丝、缆绳或锁链来施加动力。滑轮表面开槽，这可以通过绳索来改变力的作用方向和作用点。滑车由安装在结构中的一个或多个小轮组成，通常在一端或两端还附加转钩、吊环或类似的装置。滑车系统由吊链组成。

通常，卷扬机设计成固定装置，而绞车是悬挂的，所以，它们能够移动，例如与上方起

重机械相连的带轮小车上运动。一台卷扬机基本由转筒或卷筒构成，周围卷绕钢丝绳来提升或牵引。转筒可能是手工操作或是动力操作，通过涡轮或直齿轮进行调节。棘齿和倒齿可以防止负荷滑动；大型卷扬机还装有制动器，通常是外带式制动器。

桅杆式起重机的特征是桅杆倾斜，桅杆底端转动，外面一端承受荷载。相反，回转起重机桅杆是垂直的。桅杆式起重机是施工项目中标准的设备；这种设备也用于船上的装货与卸货，以及驳船上的挖泥施工。装有桥状结构的上方横跨其操作范围的起重机械是桥式起重机或龙门起重机。

Section C　脚手架

**简介**

脚手架是一种临时结构，用于建筑内外的支撑和建筑结构的维修。脚手架是施工领域的必要条件之一。无论大型结构或小型房屋，脚手架均是不可或缺的部分。在英国和欧洲大部分国家，脚手架由钢管制成，而在亚洲国家仍然使用竹制脚手架。

脚手架主要由三部分构成：脚手管、连接各脚手管的接头以及脚手板，形成了供人们施工操作的支撑空间。脚手架很少单独使用，常常通过杆件与建筑物联系起来。其他一些常用材料，包括基础板、梯子、绳索、锚拉杆、侧撑杆、起重滑轮以及围护板等。我们很少见到单独搭设的脚手架，同和结构相联系的脚手架相比，这种脚手架很不稳定。

脚手管由钢或铝制成，钢管常常要镀锌，铝管由于质量轻、韧性好而更加耐用。脚手板由干燥的木材加工而成，标准厚度范围在 50～63 mm。

**脚手架安全**

由于脚手架是现场设计结构，因而其生产的部件应尽可能灵活多样，以满足不同的设计安装要求。基础必须要求稳固。尽管基础板在脚手架使用中必不可少，但是在混凝土或类似坚硬地面上，可以不使用基础板。工作平台要求一些构件是安全的，要有密布板、双重护栏以及抵趾板。入口也要采取安全措施。脚手架是独立的结构，为保证稳定，通常要将联系杆件与相邻建筑物或其他不动的结构进行连接。

施工脚手架在世界各地都有不同的规定。一些国家针对施工用脚手架制定了使用规则，以及严格执行的规范和标准。英国也制定了严格的指导规范，脚手架施工要按照《供应和使用工作用具条例》标准执行。

**脚手架种类**

脚手架包括独立式或桥式脚手架、单柱脚手架、悬挂式脚手架、悬挑脚手架以及吊架脚手架。下面是常见的脚手架：

**连接件脚手架**　之所以称其为连接件脚手架，是因为脚手管通过连接件搭接而成的脚手架。(如图 6.1)由于强度较大，常用于承受较大的荷载，或是用于为到达多个楼层高度而必须搭设的多层操作平台。这种脚手架使用起来很灵活，可按要求组装成多种形式，但其缺点是组装的正确性较难保证。

**门式或装配式脚手架**　装配门式脚手架用途广泛、经济、便于使用，因此是最常用的脚手架类型。承包商、粉刷匠等常常在一二层住宅中使用，不过建造大型项目时，这种组合式框架也能搭建好几层高(如图 6.2)。

**液压式脚手架**　液压式脚手架设计独特，它是由支撑在沿着竖直杆上下移动的支架上的操作平台组成的。设计的支撑架升降方式形同于汽车的液压千斤顶(如图 6.3)。因为容易调整竖向高度，所以液压式脚手架有一定的使用要求，而且成本相对较低。

**移动式脚手架** 移动式脚手架是一种装有滚轮或转轮的落地式脚手架(如图 6.4)。它们容易移动，常常用于工人不停地改变操作位置的情况，如粉刷和抹灰工作。

**摇摆脚手架** 摇摆脚手架是通过悬挂的绳索来达到升降，而非升降设备，主要用于接近顶棚或顶棚下方的施工操作。悬挂用绳索必须安全锚固，这通过使用工作面上方的屋顶结构构件得以实现。提供锚固点的构件一定要经过仔细检查来评价它的可靠性。至少要使用 6 根分开的绳索悬挂，每一根绳索两端都要求足够安全。与其他脚手架类似，操作平台是由横杆、拉杆和带有防护栏和抵趾板的木制脚手板组成，应该仔细检查平面尺寸超过 2.4 m×2.4 m 的操作平台，确认管状支撑构件没有超载。

**脚手架伤害**

尽管脚手架施工成本低并且易于安装，但脚手架也有许多危害。

每年估计有 65%的施工单位或 2300 万施工人员通过使用脚手架，来接近难以到达的建筑施工区域。在英国，每年大概超过 50 人死于脚手架倒塌事故，4500 人由于脚手架故障而受伤。这样，大部分常见现场事故因脚手架引起就不足为奇了。

导致伤亡的主要事故包括：

- 因缺乏保护措施引起的高空坠落；
- 由于结构不稳定或超载引起的脚手架倒塌；
- 被坠落的工具、材料或碎片等击中；
- 因接近脚手架上方的电线而引起触电。

为确保安全，应该按照设计师的指导和脚手架设计图纸来安装。一个从事高度超过地面 12 ft(约 3.7 m)的脚手架安装人员必须获得技能证书。脚手架安装要配备安全带、绳索和其他的能够紧固的配件。针对脚手架的常规监测和日常检查等工作也不能忽视。在许多国家，都要对施工现场脚手架进行随机检查，以确保能够符合安全使用要求。



## Grammar：专业英语的翻译技巧(III)——词义引申

### Translation Skills of English for Professional Purpose Ⅲ—Extension of Meaning

所谓翻译技巧，是前人通过长期的翻译实践，对比英语和汉语这两种不同语言的特点总结出来的表达规律。掌握了翻译技巧，就能够顺利地解决许多翻译中的难题。

词义引申就是翻译技巧中的一种方法，它是指改变原有单词字面意思的翻译方法。在翻译时，有时会遇到某些词或词组由于其多义性或者英汉词汇搭配习惯的不同，在词典里找不到适当词义的情况，如果照搬词典所给的字面意思直译出来，不是词义不当，就是意思含糊，甚至造成误解。这种情况下，通常的处理办法是根据上下文、逻辑关系或用词搭配上的需要，从其基本含义出发，进一步加以引申，选择适当的词义来表达，使原文的内容实质在流畅自然的译文中确切充分地再现出来，此即为“词义引申”。

词义引申时，往往可以从词义转译、词义具体化、词义抽象化和词的搭配四个方面来考虑。

1. 词义转译

在英译汉的过程当中，如果遇到一些无法直译或不宜直译的词或词组，应根据上下文和逻辑关系进行引申转译。

【例 1】 The choice of material in construction of bridges is basically between steel and concrete, and the main trouble with concrete is that its tensile strength is very small.

钢材和混凝土是桥梁建筑的基本材料，混凝土的主要缺点(不译为“麻烦”)是抗拉强度很低。

【例 2】 If iron is kept moist, rusting is rapid, which might lead us to think that water was the influence causing the corrosion.

如果铁保持潮湿，就锈得快，这就可能使我们认为水是引起锈蚀的原因。(不译为“影响”)

【例 3】 Oxygen forms about one fifth of the atmosphere.

氧约占大气的 1/5。(不译为“形成”)

2. 词义具体化

英译汉时，有时需要根据汉语的表达习惯，把原文中某些比较抽象而笼统的词义引申为比较明确而具体的词义，以避免译文晦涩费解。翻译这一类词时，应该掌握该词的确切含义，从而在译文中作具体化的引申。

【例 4】 The purpose of a driller is to cut hole.

钻床的功能是钻孔。

【例 5】 Other things being equal iron heats up faster than aluminum.

其他条件相同时，铁比铝热得快。

【例 6】 When we speak, sound waves begin to travel and go in all directions.

我们说话时，声波就开始传播，并向四面八方扩散。

3. 词义抽象化

英语有时用表示具体形象的词或短语来表示某种特性、事物、概念等。将此译成汉语时，往往要将这种含义或短语作抽象化的引申，用比较笼统概括的词加以表达，以使译文明快达意。

【例 7】 They have their smiles and tears.

他们有自己的欢乐与悲哀。(不译为“微笑和眼泪”)

【例 8】 Rocks made under water tell another story.

水下形成的岩石说明了另一个问题。(不译为“讲另一个故事”)

【例 9】 We have progressed a long way form the early days of aerial surveys.

航空测量自从出现以来已经有了很大的发展。(不译为“已经前进了很大一段路”)

4. 词的搭配

英译汉时，要注意动词与名词，以及形容词和名词的搭配，遇到不合乎汉语的搭配习惯

时，可以将动词或形容词的词义加以引申，以适合名词，并符合汉语的搭配习惯，而不应受原文字面意义的束缚。

(1) 引申形容词以适应名词：

【例 10】 An insulator offers a very high resistance to the passage through which electric current goes.

绝缘体对电流通过有很大阻力。(不译为“高阻力”)。

【例 11】 The sun’s heat offers an almost limitless source of power.

太阳热提供了一个几乎取之不尽的动力源泉。(不译为“无限的动力源泉”)

(2) 引申动词以适应名词：

【例 12】 Rubber, porcelain and glass are commonly used to resist electric current.

橡胶、陶瓷和玻璃常常用来隔绝电流。(不译为“抵抗电流”)

【例 13】 Some plants have flowers but do not seed.

有些植物开花，但不结果。(不译为“有花”)

值得强调的是，词义引申的目的是为了使译文更忠实、更通顺、更完整地表达原文的意义。因此，引申必须得当适度，切忌忽略原文固有的基本含义、脱离开上下文的逻辑联系而妄加发挥。这样，就能从日常的翻译实践中积累经验，掌握好词义引申这一翻译技巧。

# Chapter 7

## Hydraulic Structures

### Section A Dam

A dam can be defined as an impervious barrier or an obstruction constructed across a natural stream or a river to hold up water on one side of it, up to a certain level. The side on which water is getting stored is called upstream side and the other side is called downstream side. The stored water on the upstream side constitutes the reservoir.

The construction of a dam across a river results in the ponding of water on its upstream side and this serves many useful purposes for mankind for water supply, irrigation, **navigation**, **power generation**, flood control and **breeding fish**. A dam with its green surroundings forms an excellent place for recreation purposes such as boating, swimming and water skiing. Besides the above mentioned purposes a dam serves many miscellaneous purposes, such as adding beauty to the place where it is located and makes it a place of tourism importance. A dam therefore is the central structure in a multipurpose scheme aiming at the conservation of water resources. The multipurpose dam holds special importance in the underdeveloped countries, where a small nation may reap enormous benefits in agriculture and industry from a single dam.

Dams are broadly classified into two categories: rigid dams and non-rigid dams. They are on the basis of the type and materials of construction, as gravity, arch, **buttress**, rock fill, and earth-fill dams, etc. The first three types are usually constructed of concrete, belong to rigid dams. As the name implies, these dams are constructed using rigid construction materials, such as stone or brick or reinforced cement concrete or plain cement concrete. The basic cross-sectional profile of a rigid dam is triangular.

A **gravity dam** can be defined as a structure which is designed in such a way that its own weight resists the external forces. This type of dam is more durable and has maximum rigidity, and requires less maintenance when compared to other type. The following forces must be considered in the design of gravity dams: (1) weight of the dam; (2) hydrostatic forces; (3) **uplift force**; (4) ice force; (5) earthquake force; (6) reaction. A gravity dam is generally straight in plan, although sometimes slightly curved. A gravity dam may fail due to overturning, sliding, and crushing at the toe. Generally a gravity dam will be designed with a higher factor of safety and check will be made for the above possible failures.

Arch dams transmit most of the horizontal thrust of water behind them to both banks of the river valley by arch action and may have thinner cross sections as compared with gravity dams. Arch dams can be used in V-shaped narrow river valleys, where the walls can withstand the thrust produced by the arch action. They can be built in U-shaped river valleys too, if conditions permit. In

some cases, multiple arch dams are built in broader valleys.

The simplest of the many types of buttress dams is the slab type, which consists of sloping slabs supported by buttresses. Buttress dams are less massive and can be constructed where foundation soil is relatively weak. Enormous space available between buttresses can be advantageously used for installing water treatment plants and powerhouses.

**Earth-fill dams** and **rock-fill dams** belong to non-rigid dam. Earth-fill dams are made of soil with minimum processing using primitive equipment. These are built in areas where the foundation is not strong enough to bear the weight of a gravity dam. Rock-fill dams are made of loose rocks and boulders piled in the river bed. A slab of reinforced concrete is often laid on the upstream face to make it water tight. These are more stable than earth dams and less stable than gravity dams. The dam section generally consists of dry rubble stone **masonry** on the upstream side and loose rock fill on the downstream side. Rock-fill dams are subjected to more settlement problems which may even result in the cracking of the reinforced concrete **membrane** on the upstream side. It has got better resistance towards earthquakes because of its flexible nature. The structural design of this type of dam is a bit complicated when compared to other types.

As the construction material of non-rigid dams are ordinary soil or rocks which are cheaply available, the cost of construction will be less than that of rigid dams. Non-rigid dams have a **trapezoidal** basic profile, and they have some means for controlling **seepage** by virtue of an impermeable core or an upstream blanket. Curved dams may combine both gravity and arch actions to achieve stability. Long dams often have a concrete river section containing a concrete **spillway** and **sluice** gate, while for the remainder of their length rock-fill or earth-fill wing dams are built.

If a dam fails, the floodwater will cause heavy losses. Therefore, great care must be taken in its design, construction and operation. The selection of the best type of dams for a given site is a problem both in engineering and economy. Some of the factors that govern the solution of the problem are **topography**, **geology**, **hydrology,** and climate. The choice of type of dam depends largely on the foundation conditions and availability of materials. For example, the type of dam will often depend on what local materials are available. That is to say: the relative cost of the various types of dams depends mainly on the availability of construction materials near the dam site and the accessibility of transportation facilities. Where solid bedrock is at or near the surface, a concrete gravity dam may be the logical choice. Where bedrock is a considerable distance below the surface, an earth-fill dam is usually more economical. Where the river valley is narrow and has sound rock formations, an arch dam may be the best solution. Where large quantities of rock are found, or become available for channel and powerhouse excavation, a rock-fill dam may be considered. Normally, the choice of the type of dam can only be made after a number of different, preliminary, dam designs and cost estimates have been worked out. The climate factor must also be considered, for instance, because concrete spalls or cracks when subjected to alternate freezing and thawing, arch and buttress dams with thin concrete sections are sometimes avoided in areas subject to extreme cold.

Before the design and construction of a dam, an extensive survey and study of the site must be made. This survey examines not only topographical features of the area, but also soil and rock samples to determine the geological factors that may affect the design and construction. The

**hydraulic** features of the stream or river that will be dammed must also be determined. Engineers use this information to calculate the potential water pressure. Even after the site has been made, the preliminary work is still not complete. Scale models of the dam are often made so that they can be tested under simulated conditions. Computers are also used extensively to calculate all the different loading conditions, to which such huge structures can be subjected, including those that may be caused by earthquakes.

The velocity and pressure of the water that is being blocked are important factors in the design of dams. Another factor is the possibility of seepage under foundations, often requiring special protective features in the design. Seepage is the slow leaking of water through a porous material, such as earth or some kinds of rocks like **limestone** or **sandstone**.

Many dams have other auxiliary structures, depending on the reason why the dams were constructed. One feature is a spillway that allows the floodwater or excess water from the reservoir behind the dam to be released downstream. In **embankment** dams, spillways are ordinarily constructed at one side of the dam. In concrete gravity dams, the sloping downstream face often acts as the spillways. In this case some kinds of footing or special device must be placed at the bottom of the dam so that the water is projected out into the stream where it cannot erode the dam's foundation.

Other openings are necessary when the dam is used for irrigation or for generating electricity. Gates are built in the dam through which water can be released for these purposes. The **ducts** are equipped with screens so that floating objects cannot pass through them. The ducts that carry water from the gates to turn **turbines** in a powerhouse are called **penstocks**. Some dams have **fish ladders** that allow fishes in the river to travel past the dam to or from their breeding grounds.

## Words and Phrases

navigation [ˌnævi'geiʃən] *n.* 航行(学)；航海(术)，航空(术)
power generation 发电
breeding fish 鱼类饲养
buttress ['bʌtris] *n.* 扶壁，扶垛
gravity dam 重力坝
uplift force 上浮力
earth-fill dam 土坝
rock-fill dam 堆石坝，填石坝
masonry ['meisnri] *n.* 石工工程；砖瓦工工程
membrane ['membrein] *n.* 表层
trapezoidal [ˌtræpi'zɔidəl] *adj.* 梯形的
seepage ['si:pidʒ] *n.* 漏，渗
spillway ['spilwei] *n.* 溢洪道，泄洪
sluice [slu:s] *n.* 水闸，闸门，(用水闸控制的)水有闸人工水道
topograph ['tɔpəgrɑ:f] *n.* 地形，地貌，地势
geology [dʒi'ɔlədʒi] *n.* 地质学
hydrology [hai'drɔlədʒi] *n.* 水文
hydraulic [hai'drɔ:lik] *adj.* 液力的，液压的

limestone [ˈlaimstəun] *n.* 石灰岩
sandstone [ˈsændstəun] *n.* 砂岩
embankment [imˈbæŋkmənt] *n.* (道路的)路堤；(河流的)岸堤
duct [dʌkt] *n.* 管道，槽，输气管
turbine [ˈtəːbin] *n.* 涡轮机
penstock [ˈpenstɔk] *n.* 水道，水渠，压力水管，水阀门
fish ladder 鱼梯(鱼类通过水坝的通道)

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. A dam ________ its green surroundings forms an excellent place for ________ purposes such as ________, ________and ________.

2. The dam section generally ________dry rubble stone masonry on the ________ side and loose rock fill on the ________ side.

3. In this case some kinds of ________ or special device must be placed ________ the bottom the ________so that the water is projected out into the stream where it cannot ________ the dam's foundation.

Ⅱ. Translate the following passages from English into Chinese.

It is necessary for economic consideration that the materials required for the dam should be available in close vicinity to the site. For a concrete dam, if natural material or good rock for making the aggregates is available, it is desirable. If limestone is available nearby it may be possible to replace Portland cement partially or wholly.

The water stored on the upstream side exerts a major disturbing force on the dam. In addition to this, water may seep through the body of the dam and below the foundation of the dam. This will cause uplift of the dam which also affects the stability of the dam. There are also wave pressure, ice pressure, pressure due to earthquake forces, etc. affecting the stability of the dam. Of the above, pressure due to earthquake is significant and this has been the major cause for serious cracks in several dams.

The height of a dam is defined as the difference in the elevation between the roadway, or spill crest and the lowest part of the excavated foundation. However, figures quoted for height of dams are often determined in other ways. Frequently the height of a dam is taken as the net height above the old riverbed.



# Section B Hydraulic Engineering

**Hydraulic** engineering is a branch of engineering related to the use and control of water. It is concerned with the reasonable usage of natural water resources, such as ocean, river, lake and underground water, and the prevention of water disasters, with the help of hydraulic structures. Therefore, it is also concerned with the building of hydraulic structures and the management of

such processes.

Hydraulic engineering includes such branches as waterway transportation, waterpower generation, improvement of soil by water, water supply and drainage and **piscatorial** water usage. In these branches, whether it be the water resource usage or it be the water disaster prevention, hydraulic structures need to be built. For example, in order to utilize the energy stored in water, the water level should be raised by building dams to form the necessary water head needed to drive water power generators. **Water-route signs**, harbours, break-waters as well as special structures for ship manufacture and maintenance must be built for shipping enterprises. River routes also need to be dredged up to maintain proper functioning, and ship gates are needed. In water conservancy projects for irrigation, drainage and flood prevention, various special structures need to be built: these are called **hydraulic structures**.

These various aspects of hydraulic engineering can be combined to form comprehensive projects. For example, a river can be used for shipping, energy, water supply, irrigation and fishery. A reservoir built in a river can alleviate flooding, regulate irrigation, be used for a power plant, and improve shipping and **fishery**.

Social and economical factors also play an important role in the planning of hydraulic engineering projects. The interests of various divisions may be in conflict, solving these conflicts in a comprehensive way is vital for the correct planning of hydraulic engineering projects.

## Waterway Transportation

In all types of the surface transport systems, water transport is almost as old as human habitation on this globe. Man initially exploited the resources use in water transport as a means of travel from place to place. This resulted in the discoveries of new continents and new resources and a need for large, better designed and equipped sea going vessels was felt. A waterway must be sufficiently deep to allow the passage of ships. Different ships have different requirements. Also navigation marks should be provided.

The potential for waterway transportation in our country is also great. Rivers that can be used for transportation total about 100,000 km. In addition, there are numerous bays and estuaries with deep water along the coastline. These are very suitable for constructing harbours. Therefore, water control and water conservancy play an important role in China. They are closely related to the lives and work of the Chinese people.

## Seaport

A seaport is one which provides sheltered berthing for ships and has facilities for embarking and disembarking of passengers, loading and unloading of varied cargo, storing and sorting of various consignments and servicing of ships. It is a transportation center. A harbour is the main component of a seaport which is a partially enclosed water area where the ships can find refuge from storms and waves. Here, there are facilities for refuelling, repairs and cargo handling in addition to other services. Harbour structures play an important role in the hydraulic engineering, which are explained in succeeding sections of this book.

## Water Power Generation

Water power **schemes** are some of the largest, most expensive and most interesting civil engineering structure. We have only to think of the **Niagara** Falls power scheme, the Aswan High Dam or the Volta River or the Snowy Mountains projects to realize this. What is more, the construction of water powerplant is often associated with comprehensive utilization of rivers, resulting in significant advantages to national economy. The Aswan High Dam across the Nile in Upper Egypt, increases the **cultivable** area of Egypt by no less than 30 percent and controls the flooding of the Nile and also provides 500 **megawatts** of electricity.

A typical water powerplant is composed of a **reservoir**, a plant building usually made of reinforced concrete, a water turbine connected to an electric generator in the building, and other mechanical/electric equipment. A reservoir plays an important role in maintaining the balanced working condition for a hydro-power plant. The water stored in the reservoir can guarantee the required flow rate for the water turbine not to be influenced by the natural variations in flow rate. This in turn guarantees that the customers can obtain the electric energies they require.

## Irrigation

In agriculture, if the natural supply of water to the soil is insufficient, artificial water supply to the crops-irrigation-is needed to guarantee the normal growth of crops. In many cases the water is taken from a reservoir. Usually the water in a reservoir is first used for power generation and then used for irrigation. Thus, an irrigation system is built, which includes water source, water intake structure, channels or pipes for water diversion and distribution, structures associated to the channel net, channels for discharging excessive water.

The problems associated with the design of irrigation systems, e.g. determining the irrigation area, the amount of water and water source, methods for water intake and irrigation, distribution of the irrigation system, detailing of the structures, etc., must be solved by collaboration among hydraulic engineers, agriculturalists, and economists.



## Drainage

Drainage involves artificially removing the excessive water from a field and soil. The excessive water can be harmful to crops and may form swamps.

Drainage techniques including the following: (1) to reduce water intake by building dykes to hold back water, digging channels to stop water, etc.; (2) to use drainage ditches to carry away surface water and ground water. In cities and industrialized regions, the drainage system is always underground.

## Soil and Water Conservation

Soil erosion is the phenomenon of soil being washed away by wind and water. On one hand soil erosion removes surface fertile soil, and on the other hand, it increases the amount of **sediment** in rivers which can cause fill up and even desolation of the river. Furthermore, the erosion makes the ground less capable of being infiltrated by rain water, resulting in more frequent floods. In order

to avoid these disasters, the **infiltration** capacity of the ground should be increased to reduce the amount and velocity of runoff. The soils should be made to increase its ability to withstand erosion. Such work of sustaining water and soil is the so-called soil and water conservation.

## Flood Control

Dykes can be built to prevent river flooding. However, in most cases the dykes alone cannot finally solve the problem. With the sedimentation process the river bed will be gradually raised. Therefore, comprehensive measures must be taken in modern flood control. In addition to building **dykes**, there are still other two main aspects in flood control. One is to increase the discharge capacity of the river, e.g. by dredging up the river bed and the other is to intersect and store the flood water in the upper reaches, e.g. by building a dam there to regulate the runoff. It should be emphasized that soil and water conservation is the fundamental measure in flood control because the runoff can be significantly reduced.

## Water Supply

Water supply should be sufficient in quantity and good in quality. First, the amount of water should be estimated, and then the water source should be determined and its water quality analyzed. A water supply system includes three parts: water intake, water treatment, and water distribution. The water source has the most influence on the water supply system.

Surface water, e.g. river water, is often muddy and contains relatively large quantities of organic substance and bacteria and relatively small quantities of minerals. So it is mainly suitable for industrial usage. Ground water is usually suitable to be the water source for drinking water supply system.

The main methods of water treatment include clarification (sedimentation and **filtration**), **sterilization** and softening. Sometimes the process also includes **deferrization**, **distillation** and air elimination.

## General Description of the Three Gorges Project

In the last hundred years there have been great developments in hydraulic engineering. Huge waterpower plant, canals several hundreds kilometers long, and **colossal** irrigation and drainage projects have been built. The Three Gorges Project in China is the most famous.

The main structure of the **Three Gorges Project** consists of the **water impounding dam**, **flood releasing installations**, power plants, and navigation facilities. The dam is a concrete gravity type with a max height of 175～185 m and total length of 2,500～2,800 m. The **spillway** section is built in the middle of the river channel. There are two power plants at the toe of the dam. The navigation facilities are arranged on the left bank.

## Words and Phrases

hydraulic [hai'drɔ:lik] *adj.* 水力的，水压的
piscatorial [piskə'tɔ:riəl] *adj.* 渔业的，渔民的
water-route sign 航标

hydraulic structure 水工结构
fishery [ˈfiʃəri] *n.* 渔业，水产业，渔场，养鱼术
scheme [skiːm] *n.* 安排，配置，计划，阴谋，方案，图解
Niagara [naiˈægərə] *n.* 尼亚加拉河(在加拿大和美国之间)
cultivable [ˈkʌltivəbl] *adj.* 可耕种的，可栽培的
megawatt [ˈmegəwɔt] *n.* 兆瓦特
reservoir [ˈrezəvwɑː] *n.* 水库，蓄水池
sediment [ˈsedimənt] *n.* 沉积，沉淀，沉淀物，沉降
infiltration [ˌinfilˈtreiʃən] *n.* 渗透
dyke [daik] *n.* 堤坝
filtration [filˈtreiʃən] *n.* 过滤，筛选
sterilization [sterilaizeiʃən] *n.* 杀菌，绝育
deferrization [difəraiˈzeition] *n.* 除锈，除铁
distillation [distiˈleiʃən] *n.* 蒸馏，蒸馏法，蒸馏物，精华，精髓
colossal [kəˈlɔsl] *adj.* 巨大的，庞大的
Three Gorges Project 三峡工程
water impounding dam 蓄水大坝
flood releasing installation 泄洪设施
spillway [ˈspilwei] *n.* 溢洪道，泄洪道

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The huge weight of ________ could cause problems in ________ soil. A building usually affects only ________ soils, while a hydraulic structure can affect soils as deep as tens or even hundreds of meters. Knowledge on _______ is therefore critical to a hydraulic ________.

2. The construction and maintenance of hydraulic structures are closely related to ________. Such phenomena as water ________, ________of water passed within a unit time, flow ________, ________ formation and ________ content in water are most interesting to hydraulic engineers. For offshore structures, the study of ________ and ________ is also important. Knowledge on ________is also indispensable to a ________ engineer.

Ⅱ. Translate the following passages from English into Chinese.

In ancient times, man already tried to make rivers serve their needs. Rivers provided the water necessary for drinking and irrigation and were the most economical way of transportation. Rivers were also used as defending lines against invading enemies. The techniques involved passed from generation to generation and eventually became a branch of science.

The main factors affecting soil erosion are precipitation, wind, temperature changes, surface slope, properties of soil and vegetation coverage. Measures used to prevent erosion in agriculture and forestry include increasing the organic content of soil, crop rotation, improving farming method, covering slope with vegetation, contour planting, strip planting, forestation, etc.

## Section C Harbours

A harbour is a waterway transportation center. There are two classes of harbours, namely, natural harbours and artificial harbours. Chennai and Tuticorin harbours are artificial harbours where a portion of sea is enclosed by the construction of suitable **breakwaters**. Mumbai and Cochin have natural harbours where the ships get protection by existing islands, bays and mountains around the water spread. Harbours are further classified as military, commercial, fishing and refuge harbours.

To fulfil its function, a harbour project usually includes the following: (1) protection structures, e.g. breakwaters, to protect against the actions of—waves, sea currents, wind and silt; (2) harbour structures for ships to stop and to be loaded and unloaded; (3) structures for ship manufacturing and maintenance; and (4) lighthouses and other navigation marks.

River ports serve for landing of **freight** from river boats and barges in up country locations. Some river ports are developed at a **river mouth** for serving ocean traffic. Koikata (Calcutta) harbour is an example. A harbour requires extensive area for its operation. The extent of area depends on the sizes, number and types of ships which it attracts. Considerable space is required for a ship at anchor in a **harbour basin**. So, the harbour basin has to be planned for receiving the ships, anchoring them, **mooring** them to **wharves** for loading and unloading operations and for guiding the ships out of the basin after loading operations. The basin is to be planned taking **future traffic** requirements in terms of changes in size, weight and draft of ships. In addition, sufficient land area should be provided for corresponding increase in shore operations.

A marine **terminal** is that part of a port or harbour which provides **docking** for ships, **cargo handling** and storage area**.** The **wharf** area exclusively used for passenger **embarkation and disembarkation** and light cargo transshipment is called a **passenger terminal**. When cargo traffic is the main function, the terminal is referred to as a freight or cargo terminal. When ores, petroleum products, cement and grains are stored and handled, it is known as a bulk cargo terminal.



### Port Planning and Location

The factors contributing to the decision to locate a port are its need, economic justification, prospective **tonnage of goods** to be handled, adequate inland water and land communication. After taking a decision for planning a port, technical studies of the harbour are made. Several locations need to be studied for finding the most protected location. The construction and maintenance of port structures are closely related to the study of sea level and wave actions. Therefore, knowledge on hydrology is also indispensable to an engineer. In addition, the site investigation usually involves in topography, geology and collection of information regarding wind.

After planning and designing of harbour, it is a sound engineering technique to conduct the testing of hydraulic models of the harbour layout.

### Breakwaters

A breakwater is a structural construction in the sea to provide an enclosed **water basin** for safe **berthing** of ships. The breakwater has an opening known as the harbour entrance with enough

channel depth for navigation. The purpose of a breakwater is to break the force of the sea waves.

There are different types of breakwaters. Natural rock, concrete or a combination of both are extensively used in the construction of breakwaters. Steel and timber are also used in the construction. Sometimes, the breakwater is so designed and constructed to serve the dual purpose of giving protection and becoming a part of a **pier** or a supporting roadway. In the former case, it is termed as a **breakwater pier** or **quay** and in the latter, a **mole**.

The type of breakwater selected for any harbour is based on the availability of construction materials, condition of sea bottom, functions in the harbour, the depth of water in the basin, the manpower, period and equipment available for construction. Vertical type of breakwater are limited to a depth of 20 m or less, below water level due to practical considerations.

## Wharves, Piers

A dock is a general term used for a marine structure for mooring or tying of ships. More specifically, a dock is referred to as a pier, wharf or a **bulkhead** in American practice. In European **terminology**, they are referred to as **jetty,** quay and quay wall.

A wharf or a quay is a dock for ships which is parallel to the shore. A bulkhead or quay is similar to a wharf but is away from the shore line and is packed up by ground. A pier or a jetty is a dock which is projecting into the water. The pier may be perpendicular or inclined to the shore line. Compared to a wharf, a pier may be used for docking on both sides. A pier is also referred to as a mole and is termed as a breakwater pier in combination with a breakwater.

## Berthing structure

It is a facility where the vessel may be safely moored. The **berthing** structure can be classified as vertical face type or open type structure, in vertical face structures, sheet pile wall, **block wall**, **caissons** are used. Further, they are classified on the basis of the type of cargo handled. The Chennai port outer harbour basin has **oil berth** and **container berth** where oil, ore and containers are handled respectively.

It is an essential component of the harbour and ports. It is necessary to build the ships, repair and renovate the ships. In every harbour some sort of repair facilities for ships are desirable. In **terminal ports** these facilities are essential. The old practice for harbours with some **tidal range** was to push up the vessel at high tide and leave it there beached, when the **tide recedes.** For this, an easy gradient of the ground and hard bottom to take the weight of the ship, are necessary. The practice is quite satisfactory for **sailing crafts** and even now, in some ports, where a huge number of sailing crafts take shelter during monsoon and need annual inspection, this is perhaps a very cheap method.

## Transit sheds

A **transit shed** is a necessary facility attached to a berth. A port, therefore, does not charge any **rental** for its use. But, as it is a facility only for goods in transit, a certain period, usually 3 to 5 days, is prescribed for its free use. Beyond this period **demurrage** is charged. The idea of demurrage is to discourage the use of a transit shed beyond the free period allowed. In doing so the space can be

used for other **cargo** and thus more cargo could be handled at the berth. Demurrage charges are usually at increasing rates as the period of occupancy increases.

## Dolphins

**Dolphin** is a structure located at the entrance of a **locked basin** or alongside a wharf of a pier, to absorb the impact force of the vessel or to provide mooring facility. **Breasting dolphins** are designed to take the impact of the ship when docking and are equipped with fenders. They also usually have **bollards** or **mooring posts**. Breasting dolphins are in front of the sea-face of the berth. **Mooting dolphins** are located behind the seaward face of the berth and hence are not hit by the ship. The mooring dolphins are usually smaller than the breasting dolphins.

## Mooring accessories

Mooring is referred to the parking of ships or **vessels** in harbour. In a sheltered harbour, natural or artificial，but there should be a water area where ships can wait. This area, which will have sufficiently deep water and will be out of the path of harbour channel, is called the anchorage or anchorage area. Normally, ports provide wharves and jetties for berthing of vessels so that cargo and passengers can be moved conveniently. The mooring accessories include **mooring buoy**, anchor, **mooring chain**, **floating hose**, **mooring pendent**, **floating buoy**, etc.

## Navigational aids

These are the accessories used to guide the ships in their routes and to warn them of hit and danger. They give information about the hidden dangers. There are several accessories and aids available to help the ships to avoid such dangers. The navigation lights commonly adopted are lights along the coast, light ships, light house, fixed lights (on piers, wharves and dolphins) and beacon light.

## Words and Phrases

breakwater [ˈbreikwɔːtə] *n.* 防波堤
freight [freit] *n.* [英] (船运的)货物；[美] (水上、陆上、空中运输的)货物
river mouth 河口
harbour basin 港池
mooring [ˈmuəriŋ] *n.* 系留；停泊
wharf (wharves) [hwɔːf] *n.* 码头(复数)
future traffic requirement 远景交通需求
terminal [ˈtəːminəl] *n.* 卸货[特种]码头，转运基地
docking [ˈdɔkiŋ] *n.* 停泊
cargo handling 货物装卸
embarkation and disembarkation 上船下船
passenger terminal 客运码头
tonnage of goods 货物载重量
water basin 水池
berthing [bəːθiŋ] *n.* 停泊地

pier [piə] *n.* 凸式码头；防波堤
breakwater pier 防波堤
quay [kiː] *n.* 码头，驳岸
mole [məul] *n.* 防波堤
bulkhead [ˈbʌlkhed] *n.* 船壁
terminology [ˌtəːmiˈnɔlədʒi] *n.* 术语
jetty [ˈdʒeti] *n.* 突堤，防波堤，码头
berth [bəːθ] *n.* 停泊，停处，泊船处，锚位
block wall 打板桩
caisson [ˈkeisən] *n.* 沉箱
oil berth 油船停泊处
container berth 集装箱停泊处
terminal port 起讫港
tidal range 潮汐波动
tide recede 潮落
sailing craft 小帆船
transit shed 中转货棚
rental [ˈrentl] *n.* 租金
demurrage [diˈmʌridʒ] *n.* 滞留费
dolphin [ˈdɔlfin] *n.* (码头的)系船桩；系船浮标
locked basin 深港
breasting dolphin 前系船柱
bollard [ˈbɔləd] *n.* 柱缆桩
mooring post 停靠柱
mooting dolphin 后系船柱
vessel [ˈvesəl] *n.* 水上船只
mooring buoy 系泊浮筒；系船浮筒
mooring chain 系锚锁链
floating hose 浮式软管浮标
mooring pendent 系泊属具
floating buoy 浮标
beacon light 灯塔



## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The ________ difference ________hydraulic structures and other structures is that the former are functioning in ________. A dam is subject to huge ________. Measures must be taken to prevent hydraulic structures from ________ and from losing ________, often by increasing the ________ of the structures.

2. In ancient times, man already tried to make rivers serve their needs. Rivers provided the

water necessary for ________ and ________ and were the most economical way of transportation. Rivers were also used as ________ lines against invading enemies. The techniques involved passed ________ generation ________ generation and eventually became a branch of science.

Ⅱ. Translate the following passages from English into Chinese.

A marine terminal is that part of a port or harbour which provides docking for ships, cargo handling and storage area. The wharf area exclusively used for passenger embarkation and disembarkation and light cargo transshipment is called a passenger terminal. When cargo traffic is the main function, the terminal is referred to as a freight or cargo terminal. When ores, petroleum products, cement and grains are stored and handled, it is known as a bulk cargo terminal.

It is a facility where the vessel may be safely moored. The berthing structure can be classified as vertical face type or open type structure, in vertical face structures, sheet pile wall, block wall, caissons are used. Further, they are classified on the basis of the type of cargo handled. The Chennai port outer harbour basin has oil berth and container berth where oil, ore and containers are handled respectively.

# 参 考 译 文

## 第 7 章　水 工 结 构

Section A　坝

大坝可以定义为一种不透水的障碍物，或建造在穿越河流并拦截一面水达到一定水位的构筑物。其存储水的一面被称为上游，另一面被称为下游。上游一侧的储存水构成水库。

跨河大坝建造可以在其上游积蓄大量的水，从而满足人们供水，灌溉，航运，发电，防洪和养殖鱼等方面的要求。大坝与周围的绿色的环境相结合可用于极好的娱乐服务，如划船、游泳、滑水等。除了上述用途，大坝还有许多其他用途，如给所在地增加美景，发展当地的旅游业。因此，多用途的大坝是核心结构，主要目标是保护水资源。在一些欠发达小国家可能仅依靠单一大坝在农业和工业获得巨大的利益，对于他们而言，多功能大坝则具有特殊重要性。

水坝大致分为两类：刚性坝和非刚性坝，它们基于建筑类型和建筑材料，如重力坝、拱坝、扶壁坝、堆石坝、填土坝等。其中前三类通常是由混凝土建造的，属于刚性坝。顾名思义，这些坝采用刚性材料，如石头、砖、钢筋混凝土或素混凝土。刚性坝的截面轮廓是三角形。

重力坝可以定义为以其本身的重力来抵抗外力一种结构。这种类型的大坝有较强的耐久性和刚性最大，并且与其他类型相比需要较少的维修。下面是设计重力坝时必须考虑的因素：(1)坝的重量；(2)水体静压力；(3)上浮力；(4)冰压力；(5)地震力；(6)反应。重力坝在平面中通常是平直的，虽然有时稍微弯曲。重力坝可能会由于倾覆力矩、滑移和底部的挤压等原因失效。设计重力坝时，通常使其具有较高的安全系数，并针对上述可能的破坏进行检查。

拱坝通过拱的作用将它背后的大部分水平推力传递到河谷的两岸，与重力坝相比，它的截面可以相对比较薄。拱坝可用于 V 形狭窄河谷，那里的峡壁可以承受拱的作用所产生的推力。如果条件允许，它们也可以建立在 U 形河谷。在某些情况下，多拱坝可建在更广阔的山谷中。

在众多类型扶壁坝中，最简单的是由扶壁支撑的斜板组成的平板坝。扶垛坝不太大，可以在那些地基相对薄弱的地方建造。在扶壁间的巨大空间可以被用于安装水处理装置和发电站。

填土坝和堆石坝属于非刚性坝。填土坝是利用原始设备以土为建材而建造的坝体。这种坝建立在那些基础不足以承受重力坝重量的地方。堆石坝是由松散的堆积在河床中的岩石和石块组成的一种坝。一块钢筋混凝土板往往放在上游面，使之水紧。这种坝的稳定性介于土坝和重力坝之间。该坝断面一般包括在上游侧的碎石毛石和下游侧松散堆石。堆石坝要面对的更多是沉降问题，该问题可能导致上游一侧钢筋混凝土表层的开裂。它的柔韧性可以更好地抵抗地震作用。与其他类型的坝相比，这种类型的大坝的结构设计相对有些复杂。

由于非刚性坝的建造材料是普通土壤或岩石，取材廉价，其建设成本将低于刚性坝。非刚性坝有一个梯形侧面轮廓，并凭借不透水核心或上侧的表面对控制渗透有一定的作用。曲线坝可以结合重力作用和拱的作用来实现稳定。长坝往往有一段混凝土断面，包含有混凝土溢洪道和闸门，而剩余的长度由堆石或填土建成翼坝的坝体。

如果一个大坝被破坏了，洪水将会带来巨大的损失。因此，在其设计、建造和运行中必须小心谨慎。为一个既定场所挑选最佳类型的水坝是要解决工程和经济两个方面的问题。地形、地质、水文和气候这些因素制约问题的解决。选择何种类型的大坝在很大程度上取决于基础条件和可用材料。例如，大坝的类型往往取决于当地可以利用的材料。这就是说，不同类型的大坝的相对成本主要取决于坝址附近可用的建筑材料和可用的交通设施。凡达到或接近地表是坚实基岩的地方，混凝土重力坝可能是最佳的选择。若基岩在地表以下很深，土坝通常是比较经济的选择。若河谷狭窄，有良好的岩层，拱坝可能是最好的选择。若大量岩石被发现，作为建设发电站所使用的材料，堆石坝可能成为首选。一般情况下，选择什么类型的大坝只能在一些不同的初步的大坝的设计和成本估算工作完毕以后才能决定。气候因素也是必须要考虑的，例如，因为混凝土受到冻融作用容易破碎或开裂，所以具有薄的混凝土断面的拱坝和扶壁坝在一些寒冷地区要避免使用。

在设计和建造大坝之前，必须对坝址进行广泛的勘测和研究。勘查不仅要检查该区域地形特征，而且要采集土壤和岩石样本，以确定可能影响到设计和建造的地质因素。截断河流的水力特征也必须考虑在内。工程师使用这些信息来计算潜在的水压力。甚至在地址被选定后，初步工作仍然在继续。工程中，常常做一定比例的大坝模型在模拟条件下测试。计算机也广泛用于计算在不同加载条件下，这种巨大的结构可以承受的包括由地震可能会引起各种力。

在大坝设计中水的速度和压力是拦截要考虑的重要因素。另一个因素是基础下面渗漏的可能性，这些往往需要特殊防护措施。渗漏是水通过多孔材料缓慢泄漏，如土壤或某些像石灰岩或砂岩类型的岩石。

根据水坝被建造的原因，许多坝有其他辅助结构。一个功能是泄洪，使洪水或多余的水从大坝背后的水库释放到下游。在筑堤坝中，溢洪道通常建造在大坝的一侧。在混凝土重力坝中，倾斜的下游面往往充当泄洪道的角色。这种情况下某些种类的基础或特殊的设备必须置于大坝的底部，使水抛射到溪流中时不致削弱大坝的基础。

当坝被用于灌溉或发电时，有必要在一些位置开口。水通过坝中的门来实现上述目的。管道都配备有过滤设施，因此浮游物体不能穿过它们。在发电站中，水通过管道从门到涡轮的部分被称为水闸。一些大坝具有让游走的鱼类或繁殖区鱼类可以通过的鱼梯。

## Section B　水利工程

水利工程是关于水资源利用和水控制工程的一个分支。它主要涉及自然水资源的合理使用，例如海洋、河流、湖泊以及地下水的合理使用。与此同时，在水利结构的协助下它也能够阻止水灾的发生，因此它也涉及水工结构以及这一过程的监理。

水利工程包括诸如水路运输、水力发电，水资源对土壤的改进、给水排水以及淡水资源的利用。在这些分支当中，不管是属于水资源利用还是属于防洪工程，都需要建立水利结构。例如，为了利用储存在水里面的能量，通过建造大坝提高水头来驱动水力进行发电。航标、港口、闸门以及建立造船企业所需的生产及维护船只的特殊结构。航道和码头都需要把淤泥挖干净，从而发挥适当的作用。在水资源保护项目中，灌溉、排水、防洪等各种特殊结构都需要建造。这些都称为水工结构。

水利工程的这些不同方面能够被联合起来形成一个综合的项目。例如，一条河流能够进行船运、创造能源、水资源供给、灌溉以及发展渔业。建在河流上的水库能够缓减洪灾、有序灌溉、发电，与此同时，它也促进了船运和渔业的发展。

社会和经济因素在水利工程项目中也扮演着重要的角色，不同部门之间的利益追求可能会产生冲突，用一种综合的方法去解决这些冲突，对于水利工程项目计划的正确实施是至关重要的。

**水路运输**

对地球来说，在所有的运输体系当中，水运几乎是人类最古老的运输方式。人类最早开采资源就是使用水运的方式，并且作为从一个地方移动到另一个地方的游走一种手段。这样就导致了新大陆及新资源的发现，而体积庞大、设计良好、装备齐全的海洋通行船也随之产生了。水路必须有足够的深度以供船只顺利通过，不同的船只对水深有不同的要求，并且应当提供相应的航海标记。

在我国水路运输的潜能是巨大的，作为运输的河流总计大约有 100 000km，除此之外，沿着海岸线还有大量的海湾和深水出水口。这些条件非常适合建造港口。因此，水资源控制和水资源保护在中国扮演着重要的角色。它与中国人的生活和工作紧密相关。

**海港码头**

码头是一个为船只提供庇护的场所并且具有这样的设施：能够方便上船和下船的客人休息，各种货物的装卸及储存，同时将各种交托进行分类，为船只提供综合的服务。它是一个运输中心，港口是一个码头的重要部分，港口是能够使船只不受风暴和海浪袭击的部分封闭的海域。在这里，有一些提供燃料的设施，修理及货物处理等其他一些服务。港口结构在水利工程中有着重要的作用，这将在本书的后面部分进行介绍。

**水力发电**

水力发电项目是一些规模最大、耗资巨大和最引人注目的土木工程构筑物。我们只要想到尼亚加拉瀑布发电工程、阿斯旺高坝、沃尔特河或斯诺伊山等工程项目，就可以认识到这一点。更重要的是，水力发电站的施工经常与河流的综合利用联系在一起，因此对国民经济的发展有重要意义。阿旺斯高坝使埃及的可耕地面积增加 30%以上，并且可以控制尼罗河的洪水灾害，并提供 50 万 kW 的电力。

一个典型的水力发电站是由一个水库，一个由钢筋混凝土建造的电站，一个与发电器相连的水涡轮，以及其他的一些机械/电子设备组成的。一个水库对于维持水电站的平衡工作条件起着重要的作用，水库里储存的水能够为水涡轮提供所需的流速，以确保不被自然流速影响，进而也保证了用户所需要的电能。

**灌溉**

在农业方面，如果水对土壤的自然供给不充足，人工供给庄稼的水，即灌溉对于保证植物的正常生长就是必需的了。在许多情况下，这些水来自水库，水库中的水首先被用来发电，然后才被用来灌溉。因此，一个灌溉系统包括水资源，取水结构、渠道、配送水的管道、与

渠道网相联系的结构、排放多余水的渠道。

与灌溉系统设计相关的一些问题，例如，灌溉区域、水及水资源的数量、取水和灌溉的方法、灌溉系统的配送、结构的细部构造等必须依靠水利专家、农学专家及经济学家的合作而得以解决。

**排水**

排水涉及人工地从土壤和地中排出过剩的水，这些过剩的水对庄稼是有害的并且很可能形成沼泽。

排水技术包括：(1)通过建造堤，挖渠道来阻止水进入进水闸；(2)使用排水沟带走地表水和地下水。在城市及工业化地区，排水系统通常设在地下。

**水土保持**

土壤侵蚀是土壤被水和风冲刷的现象。一方面，土壤侵蚀移除了表面的肥沃土壤，另一方面，它增加了在河流中的沉积物，而这些沉积物可能充满河流甚至使河流荒芜。此外，水土流失使地面不能被雨水渗透，造成更频繁的洪水。为了避免这些灾难，增加地面的渗透能力从而减少径流量和径流速度，提高土壤经受侵蚀的能力，像这样的水和土的保持工作就是所谓的水土保持。

**洪水控制**

建造堤坝是为了阻止洪水，然而，在绝大多数的情况下仅有堤坝最终是解决不了问题的。随着沉淀的不断进行，相应的河床逐步升高。因此，在现代的防洪控制中必须采取综合的措施。除了建造堤防设施外，在防洪控制中还有两个主要的方面。一个就是增加河流的排水量，例如，通过疏浚河床。另一个是在上游交叉和储存洪水，例如在那里建造大坝而使径流有序流动。需要强调的是水土保持是洪水控制的基本措施，因为如果水土完好的话，径流可大大减少。

**供水工程**

水供给应该在数量上足够在质量上优质，首先，应该估计水量，然后评价水资源，分析水质。一个供水系统包括三个部分：取水、水处理和水的分配。水资源对供水系统影响最大。

地表水，如河水，往往是比较泥泞，包含大量的有机物质和细菌及相对少量的矿物质，因此它主要用于工业。地下水资源通常适用于饮用水供给系统。

水处理的主要方法包括分类(沉淀、过滤)、消毒和软化。有时这个过程也包括除锈、蒸馏和空气消毒。

**三峡工程概述**

在过去的几百年里，水利工程已经取得了很大的发展，巨大的水力发电站，成千上万米长的运河，宏大的灌溉及排水项目已经被完成。中国的三峡工程是最著名的。

三峡工程的主体结构包括蓄水大坝、泄洪设施、发电站和导航设施。大坝是一个混凝土重力坝，最大高度 175～180 m 和总长 2500～2800 m，溢洪道部分建立在河道的中间。在大坝底有两个电站，导航设施安排在左岸。

## Section C 港口

港口是水运交通的中心，主要分为以下两类：一类是自然港口，一类是人工港口。钦奈和杜蒂戈林就是两个人工港口，用防波堤围起一块适当面积的水域而形成。孟买和科钦是天然港口，四周被岛屿、海湾和山脉所环绕，成为船只的天然屏障。将港口细分，还可以分为军港、商业港口、钓鱼港口和避难港口。

为满足功能适用性要求，通常港口工程有以下功能：

(1) 起防护作用，例如防波堤起保护作用，以免受海浪、水流、风和淤泥的冲击；

(2) 为进出港船只提供装、卸货服务；

(3) 为船只提供维修和制造；

(4) 灯塔和其他航运标志。

港口为上游乡村河船和驳船提供卸货服务，有的港口地处河口处靠远洋运输发展起来，加尔各答港口就是一例。为保证港口的交通正常运作，港口需要拓展面积，拓展空间的大小取决于它其中往来船只的数量、类型和载重量。船只在港池锚定停泊时需要更大的空间，因此规划港池有以下功能：接待船只、抛锚停泊、靠岸船只装卸货、货物装好后引导船只出港。港池的规划也要考虑以后的交通需求：例如船只大小、载重量和起重等，还要为相应的岸上活动预留足够的陆地面积。

海运码头是港口的一部分，能够为船只、货船提供停泊、货物储存服务。当码头专门供旅客上船、下船和小件货物转运，即称为客运码头；当货运成为主要业务时，码头即为水运、货运码头。当主要存储和装卸铁矿石、石油、水泥和粮食时，码头即为大宗货运码头。

**港口的规划和位置**

影响港口位置的因素是：需求、经济分析、货物载重量，还要有足够的水量并与陆地相连。计划通过后，进行技术上的可行性研究。为了找到最合适、最安全的地点，应进行多方案比较。对海平面和波浪的研究对港口工程的建设和维护工作尤为重要，因此，工程师必须掌握水文学相关知识。而且，现场地址的勘测工作还包括地形、地质和当地风速等相关资料的收集。

港口的规划和设计工作完成后，最好设计一个港口模型进行水力试验。

**防波堤**

防波堤是建造在海上的构筑物，能够为船只提供一个封闭的安全的停靠港，通常防波堤中能够满足通航净空要求的通道称为海港入口，而防波堤的作用就是阻挡海浪的撞击力。

防波堤有不同的种类：天然石材防波堤、人工混凝土防波堤，或者使用两种材料混合建成的防波堤，还有用钢铁、木材制造的防波堤。有时防波堤的设计和建造能同时满足双重作用，保护作用和作为码头的一部分或连接道路的一端。前者被称为防波堤码头或码头，后者被称为防波堤。

港口防波堤的选择是基于建筑材料、海底地质情况、港口功能和最大水深、劳动力还有建筑机械、施工周期等因素的。基于实际考虑，垂直式防波堤高度应不大于在海平面以下 20 米。

**码头，凸式码头**

船坞是船只停泊的海洋构筑物术语，而且，在美国习惯称船坞为凸式码头、码头或船壁。在欧洲术语中，它们称作突堤、驳岸和岸壁。

登岸码头是与海岸线相平行的码头，船壁或码头有点像码头，但却远离海岸线，尽头通向陆地。凸式码头两侧可以同时停船，凸式码头也称防波堤，被称作防波堤凸式码头。

**停泊结构**

停泊结构是船只可以安全停泊的地方，可分为垂直式结构和敞开式结构。垂直式结构用打板桩、沉箱建成。也可以根据所处理的货物类型分类。例如深海外的钦奈港口分别储存油、矿石、集装箱，有油轮停泊处和集装箱停泊处。

港口中必备的是修理站，造船重要，修船、翻新船也重要。在每一个港口配有一些修船的设备是十分便利的，在起讫港这些设备尤为重要。古老的做法是利用潮涨潮落的波动，涨

潮时船离港，落潮时船停泊。所以坚硬的底部和岸边的微坡都有利于分担船只荷载。修理站的建立相当实用和经济，直到如今，在一些港口，每到季风季节，大量通航小船只来此寻求庇护和年检维修。

**中转货棚，通栈**

中转货棚(通栈)是联系停泊处的设施，因此，港口不收取任何费用。但是为了方便货物中转，3～5 天内不收费，超出时间限制要收缴滞留费，目的是不鼓励货物长期滞留，这样一来能节省空间容纳其他货物，提高循环使用率。当然，滞留时间越长，滞留金增长率越大。

**系船柱**

系船柱在深港的入口处或靠在码头的墩柱上的结构物，作用是吸收船只的撞击力或提供停泊设施。前系船柱被设计成配有围栏，当船只停靠时能够缓冲撞击力。前系船柱也有柱缆桩和停靠柱，在海岸面的前侧提供停靠。后系船柱则相反在海岸面的后侧，因此免受船只撞击，通常也比前系船柱要小。

**系锚附件**

系锚是港口船只的停靠。在封闭的人工港口或者自然的港口，都要有水域供船只漂浮。此处一直到港口的航道，应该有足够的水深，以供停泊抛锚，所以称为抛锚区域。为乘客和船只都能够方便，港口提供码头, 停泊处为船只系泊。系锚附件包括系船浮筒、锚、系锚锁链、浮标等。

**航海设备**

这些设备用来引航，当撞击危险来临时给予预警。它提供潜在的危险警告信息，有很多仪器和救助方式能够帮助船只避险，沿着海岸线经常采用航行灯照明，还有灯船、灯屋、固定位置的灯和灯塔。

## Grammar：专业英语的翻译技巧(Ⅳ)——词量增减

## Translation Skills of English for Professional Purpose Ⅳ—Amplification and Omission



词汇的准确翻译决不意味着形式上保持词量的相等，不允许增减一些词。相反，翻译时是允许改变词量的，而且常常是必需的。这种增加一些原文中没有的词或是减去原文中某些词的译法，就称为词量增减。

1. 词量增加

英译汉时，往往会遇到一些词句，在英语表达上是清楚的，但如果直译成中文，不是意思不清楚，便是译文不够通顺。因此，为了使译文意思明确，或者仅仅为了修辞的目的，需要增加或重复一些原文中无其形而有其义的词，即词量增加。

(1) 为了明确意思。

① 在抽象名词后增加名词。

当含有动作意义的抽象名词表示具体概念时，常常通过增加词使译文具体化。

**【例 1】** <u>Oxidation</u> will make steel structure rusty.

氧化作用会使钢结构生锈。(增加“作用”)

【例 2】 Vertical movement of arm on column is 520 mm.

摇臂在立柱上的垂直移动量是 520mm。(增加“量”)

② 在形容词前加名词。

当英语的某些形容词单独译出意思不明确时，可在其前增加名词使其更明确。

【例 3】 Piston engines are used for relatively slow planes flying at 20,000 feet or less.

活塞式发动机用于飞行速度较慢、飞行高度在 2 万英尺以下的飞机。(增加“飞行速度”)

【例 4】 According to Newton’s Third Law of Motion action and reaction are equal and opposite.

根据牛顿的运动第三定律，作用力和反作用力是大小相等，方向相反的。(增加“大小”、“方向”)

(2) 为了修辞的目的。

① 增加起语气连贯作用的词。

有时需要在译文中增加一些起连贯作用的词，主要是连词、副词和代词，从而使语气连贯，行文流畅，并达到一定的修辞目的。

【例 5】 Construction in thicker layers would lead to better heat retention and increase the time available for affective compaction.

厚层施工法既可获得良好的保热性能，又能提高有效压实度的时效。(增加“既”、“又”)

【例 6】 The question is really a route selection rather than a drainage problem.

这个问题确实与选线有关，而不是排水的问题。(增加“有关”)

② 增加概括词。

当句子中有几个并列成分时，有时可以在并列成分之后增加表示数量意义的概括词，从而起到一定的修辞作用。

【例 7】 The frequency, wave length, and speed of sound are closely related.

声音的频率、波长和速度三者是密切相关的。(增加“三者”)

【例 8】 A designer must have a good foundation in static, kinematics, dynamics and strength of materials.

设计者必须在静力学、运动学、动力学和材料力学这四个方面有良好的基础。(增加“这四个方面”)

(3) 重复法。

重复法是指在翻译时重复原文中重要的或关键性的词，以期达到两个目的：一是清楚，二是强调，从而使译文生动有力、清晰流畅。

【例 9】 An alternative way to use reinforcement is to stretch it by hydraulic jacks before the concrete is poured around it.

另一种方法是先用液压千斤顶把钢筋拉长，然后在钢筋周围浇灌混凝土。

【例 10】 A synthetic material equal to that alloy in strength has been created, which is very useful in civil engineering.

已经制造出一种在强度上和那种合金相等的合成材料，这种合成材料在土木工程中十分有用。

2. 词量减少

词量减少就是将原文中的某些词语略去不译。有些词在英语中经常出现，如介词、冠词

和关联词等，在译成汉语时如果逐词翻译，译文会显得不通顺。为了更好地表达原意，翻译时往往可以省略原文中某些词，以使译文更严谨、更精练、更明确。例如：英语中的冠词、介词、连接词、代词等。而且，在英译汉中词量减少的情况要比增加的情况更为普遍。

(1) 省略冠词。

不定冠词和定冠词在单数名词之前时可以表示类别，译成汉语时就不必译出。

【例 11】 Any substance is made up of atoms whether it is a solid, a liquid, or a gas.

任何物质，不管它是固体、液体或气体，都是由原子组成的。(省略三个不定冠词)

【例 12】 The column is the important part of a load-bearing structure.

柱是承重结构中最重要的组成部分。(省略两个冠词)

(2) 省略代词。

英语中代词使用较多，尤其是在并列句和复合句中，而汉语却较少使用代词。在英译汉时，很多情况下代词可省略不译。

【例 13】 A fine bridge engineer, Shirley Smith, who was the contractor's agent for the Forth Road Bridge, has written very well about his love of bridge work in his book *Great Bridges of the world*.

曾担任福斯公路桥承包代理人的优秀桥梁工程师雪利 • 史密斯在他的著作《世界大桥》一书中出色地表达了他对桥梁工程的热爱。(省略关系代词“who”)

【例 14】 Once a beam has been cracked by a large moment, it can never return to its original un-cracked state.

梁一旦受到很大弯矩作用而出现裂缝时，就不会再恢复到其原来未开裂的状态。(省略物主代词“it”)

(3) 省略介词。

介词在英语中使用的频率比汉语要高得多，英译汉时，许多情况下要根据汉语的习惯省略介词。

【例 15】 In winter, it is much colder in the north than it is in the south.

冬天，北方比南方冷得多。(省略三个介词“in”)

【例 16】 Most substances expand on heating and contract on cooling.

大多数物质热胀冷缩。(省略介词“on”)

(4) 省略连接词。

英语中两个句子或两个句子成分之间必须有连词或关联词，而汉语较少使用连词。因此英译汉时可将一些连词省略。

【例 17】 The density of a body can be found providing its mass and volume are known.

已知物体的质量和体积就可以求出其密度。(省略连接词“providing”)

【例 18】 In downstream areas where the river passes through a broad gentle flood plain, civil engineers may be asked to build flood protection works.

在下游地区，河流经过的广阔平缓的洪伐平原需要土木工程师修建防洪工程。(省略起连接作用的关系副词“where”)

(5) 省略动词。

① 省略谓语动词。

英语的谓语必须有动词，而谓语又是句中不可缺少的成分，所以英语的句子离不开动词。但汉语则不是，汉语可以直接用形容词、名词、介词结构、主谓结构等作谓语。翻译时，可以省略谓语动词，尤其是系动词。

【例 19】 Stainless steels possess good hardness and high strength.

不锈钢硬度大、强度高。(省略动词“possess”)

【例 20】 Stone masonry bridges are by nature strong and require very little maintenance.

石砌圬工桥梁很结实，较少需要养护。(省略动词“are”)

② 省略与具有动作意义的名词连用的动词。

【例 21】 In conduction and convection energy transfer through a material medium is involved.

在传导和对流时能量通过某种材料介质传递。(省略动词“is involved”)

【例 22】 Energy losses due to friction occur in every machine.

每台机器都由于摩擦而损耗能量。(省略动词“occur”)

(6) 省略名词。

【例 23】 The number of known hydrocarbons runs into tens of thousands.

已知的碳氢化合物有几万种。(省略名词“the number”)

【例 24】The mechanical energy can be changed back into electrical energy by means of a generator or dynamo.

机械能可利用发电机再转变成电能。(省略名词“dynamo”)

# Chapter 8

## Bridge Engineering

### Section A Bridges

Bridges are great symbols of mankind's conquest of space. It is a structure that spans obstacles, such as rivers, lakes, or gorges, to provide a roadway for traffic. By far the majority of bridges are designed to carry automobile or railroad traffic, but some are intended for pedestrians only. Bridges also support pipes, troughs, or other conduits that transport materials, such as an oil pipeline or a water aqueduct.

Humans have been constructing bridges since ancient times. For a few thousand years the classical form in bridge design has been the vault or arch. This structure, because of its inherent contour, utilized masonry as its material. The use of concrete as a building material, however, was not considered until late in the nineteen century. The first application of reinforced concrete to bridge structures was pioneered by Hennebique. In the same period prestressed concrete concepts were being formulated by Jackson and Doehring. There application was not successful because of the high losses in prestress caused by shrinkage and creep of the concrete. It was not until 1926-1928 when Freyssinet was able to control these losses with high-strength steel that prestressing was considered feasible. Prestressed concrete was widely used for bridges after about 1950. Steel became more useful for bridges with the development of stronger and more corrosion-resistant alloys. Aluminum alloys, which were used in bridges as early as 1933, greatly reduce the dead weight of the bridge, but they are not widely used because they are relatively expensive.

The principal portions of a bridge may be said to be the "superstructure" and "**substructure**". This division is used here simply for convenience, since in many bridges there is no clear dividing line between the two. Bridges may also be classed as "**deck**" or "through" types. In the **deck type** of bridge, the roadway is above the supporting structure, that is, the load carrying elements of the superstructure are below the roadway. In the **through type** of bridge, the roadway passes between the elements of the superstructure. Deck structures **predominate**: they have a clean appearance, provide the motorist with a better view of the surrounding area, and are easier to widen if future traffic requires it.

The forces that act on bridge structural members are produced by three kinds of loads: the dead load, the live load, and the occasional load. Dead load refers to the weight of the bridge itself — is usually the greatest load. Live load refers to traffic that moves across the bridges as well as normal environmental factors such as changes in temperature, **precipitation**, and winds. Occasional load refers to environmental factors that go beyond normal weather conditions, factors such as sudden **gusts** of wind and earthquakes. All three factors must be taken into consideration in the design of a bridge. The design of bridges requires the collection of extensive data and from this the selection of

possible options. From such a review the choice is **narrowed down** to a shortlist of potential bridge designs. A sensible work plan should be devised for the **marshalling** and deployment of information throughout the project from conception to completion. It has been greatly improved by the use of advanced mathematics, electronic computers, and test model, with these techniques, designers can obtain precise calculations of stresses and strains under both static and **dynamic** conditions. The designer of each medium and **long-span bridge** tries to devise a structure that is best suited to the conditions encountered at that particular location. The result is an almost **bewildering** variety of structures that differ either in basic design principle or in design details.

General categories of bridges are briefly described in the following paragraphs:

## Girder bridges

A **girder** bridge is perhaps the most common and most basic bridge. A log or a piece of other material across a creek is an example of a girder bridge in its simplest form. That piece of material — called a girder or beam — rests directly on the ground on each side or is supported on heavy foundations known as **piers**. Girder bridges come in two basic varieties: plate and box girders. Simple or continuous beam-type bridges can be made of **timber**, steel, concrete, prestressed concrete or other materials.

The precast, prestressed beam type is a popular bridge type. These bridges can be found both as overpasses and as bridges. This type of bridge became popular in the 1950s. Prestress indicates that the reinforcing is stressed before loading, thereby placing the entire concrete beam section in compression or at a low value tension stress. Since concrete is strong in compression and relatively weak in tension, this procedure creates a more effective concrete section.



## Arch bridges

A strong point **in favor of** arch bridges in their pleasing appearance and **aesthetic** elegance. **Arch** bridges can be made of bricks or stone blocks that are held together by the compressive force characteristic of the arch because tensile strength is not necessarily required for arch construction. Reinforced concrete and steel arches are altogether much lighter structures. The structure consists basically of the arch, the deck and usually some supports from the arch to the deck.

Arches may be grouped into circular, parabolic and **catenary arch** in terms of the shape of arch. With regard to structural articulation the arch can fixed or hinged. Three types of arches are used: **the fixed arch**, the two-hinged arch, and the three-hinged arch. The main supporting structure in an arch bridge is one or more **curved** elements. The dead and live forces that act on the arch bridge are transmitted along the curved line of the arch into **abutments** or supporting structures at either end.

The arch, with its simple and elegant structures, has become a classic bridge configuration.

## Cantilever bridges

To solve the problem of increasing the span distance, other alternatives to beam and arch bridges included **suspension** and **cantilever** bridges. Among the largest cantilever bridges in the United States is the Commodore John Barry Bridge.

A cantilever bridge is a bridge built using cantilevers, a cantilever is a structure or beam that is unsupported at one end but supported at the other, like diving boards. When anchored firmly, a cantilever is a very strong structure. It consists of three parts: the outer beams, the cantilevers, and the central beam. This configuration made longer spans possible and wider clearance beneath.

For small footbridges, the cantilevers may be simple beams; however, large cantilever bridges designed to handle road or rail traffic use trusses built from structural steel, or **box girders** built from prestressed concrete.

The cantilever bridge was a popular type of bridge in the first half of the twentieth century, but at present, some commentators believe that the **cable-stayed bridge** will replace it for comparable spanning distances.

## Suspension bridges

Suspension bridges are used for very long spans or for shorter spans where intermediate piers cannot be built. Of all the bridge types in use today, the suspension bridge allows for the longest spans. The principal structural elements of a suspension bridge are: **flexible main cables**, towers, anchorages, hangers, deck and **stiffening** girder. Some primitive examples of suspension bridges use **vines** and ropes for cables.

A typical suspension bridge is a continuous girder with one or more towers **erected** above piers in the middle of the span. The girder itself is usually a truss or box girder though in shorter spans, plate girders are not uncommon. At both ends of the bridge large anchors or counter weights are placed to hold the ends of the cables. Suspension bridges, when well designed and proportioned, are clearly the most aesthetically pleasing of all bridges.

## Words and Phrases

substructure [sʌbˈstrʌktʃə] *n.* 下部结构
deck [dek] *n.* 桥面，甲板，覆盖物；*vt.*装饰，修饰，打扮
predominate [priˈdɔmineit] *vi.* 占支配地位；*vt.*在……中占优势
precipitation [priˌsipiˈteiʃən] *n.* 沉淀，沉淀作用，降雨，降雨量，(雨等)降落
gust [gʌst] *n.* 阵风(雨)，骤风(雨)；*vi.* (风)猛刮
marshal [ˈmɑːʃəl] *vt.* 安排，调度，整理
dynamic [daiˈnæmik] *adj.* 动力的，动态的
bewildering [biˈwildəriŋ] *adj.* (情况)让人困惑的，令人费解的
girder [ˈgəːdə] *n.* 梁，钢桁的支架，纵梁，主梁
pier [piə] *n.* (桥)墩，支柱
timber [ˈtimbə] *n.* 木材，木料，树木，横梁
arch [ɑːtʃ] *n.* 拱，拱门，拱形物；*vt.* & *vi.*(使)弯成拱形
curve [kəːv] *n.* 曲线，弧线，弯曲物；*vt.* & *vi.*(使)弯成弧形
suspension [səsˈpenʃən] *n.* 悬挂，悬浮，吊，悬架
cantilever [ˈkæntiliːvə] *n.* 悬臂(梁)，伸臂，突梁
anchor [ˈæŋkə] *n.* 锚 *vt.&vi.* 锚固，(使)固定
stiffen [ˈstifn] *vt.&vi.* 变硬，加强，加劲

vine [vain] *n.* 藤本植物，藤
erect [i'rekt] *vt.* 使直立，竖起，建立；*adj.*竖立的，直立的，挺立的
deck (through) type 上(下)承式
narrow down (使)变窄；(使)减少；(使)缩小
long-span bridge 大跨径桥
girder bridge 梁桥
arch bridge 拱桥
in favor of 赞成，支持
catenary arch 反垂曲线形拱
the fixed arch 无铰拱
cantilever bridge 悬臂桥
box girder 箱形梁
cable-stayed bridge 斜拉桥
suspension bridge 悬索桥
flexible main cable 柔性主缆

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. A sensible work plan should be devised for the ________ and deployment of information throughout the project from ________ to completion.
2. ________ indicates that the reinforcing is stressed before loading, thereby placing the entire concrete beam section in compression or at a low value ________ stress. Of all the bridge types in use today, the ________ bridge allows for the longest spans.
3. Of all the bridge types in use today, the ________ bridge allows for the longest spans.
4. Arches may be grouped into circular, ________ and ________ arch in terms of the shape of arch.
5. Bridges may also be classed as "________" or "through" types.

Ⅱ. Translate the following passages from English into Chinese.

Precast girders may not be used for spans much in excess of 120 ft because of the problems of transporting and erecting large, heavy units. On the other hand, there is a clear trend toward the use of longer spans for bridges. Highway safety is improved by eliminating central piers and moving outer piers away from the edge of divided highways. For elevated urban expressways, long spans facilitate access and minimize obstruction to activities below. Concern for environmental damage has led to the choice of long spans for continuous viaducts. For river crossing, intermediate piers may be impossible because of requirements of navigational clearance.

The arch bridge has been a traditional style for 1000 years, and was first built for stone-paved roads for horses and carts and later for motor roads. Since liberation the arch form has been frequently used on the railway lines. There are as many as 324 medium-sized and small stone arch bridges on the Chengtu-Chungking line. As for the Paochi-Chengtu line, there are 175 on the section from the Huangsha River to Chengtu alone. Technically renovated after the traditional fashion, the new arch type has a larger span and load-bearing capacity.

## Section B Substructure of Bridge

The portion of the bridge structure below the level of the bearing and above the foundation is generally referred to as substructure. Substructure of bridge fall into two distinct categories: **end supports** and **intermediate supports**. The end supports are normally described as the "**abutments**", whilst the general term for the intermediate supports of a **multi-span bridge** is the "piers". The abutments and piers are usually constructed from in situ concrete, but precast sections can be employed to speed up the construction process.

### Piers

Special attention must often be given to the design of the bridge piers, since heavy loads may be imposed on them by currents, and floating ice and debris.

The general shape and features of a pier depend to a large extent on the type, size and **dimensions** of the superstructure and also on the environment in which the pier is located. Piers can be solid, **cellular**, **trestle** or **hammerhead** types. Solid and cellular piers for river bridges should be provided with **semicircular** cut waters to facilitate streamlined flow and to reduce scour. Other designs such as reinforce concrete framed type have also been used. Solid piers are of masonry or mass concrete. It is permissible to use stone masonry for the exposed portions and to fill the interior with **lean concrete**. This would save expenses on **shuttering** and would also enhance appearance. Cellular, trestle and hammerhead types use reinforced concrete. The cellular type permits saving in the quantity of concrete, but usually requires difficult shuttering and additional labor in placing reinforcements. The trestle type consists of columns with a **bent cap** at the top. In some recent designs, concrete hinges have been introduced between the top of columns and the bent cap in order to avoid moments being transferred from deck to the columns. For tall trestles as in flyovers and elevated roads, connecting **diaphragms** between the columns may also be provided. The hammerhead type provides slender substructure and is normally suitable for elevated roadways. When used for a river bridge, this design leads to minimum restriction of **waterway**.

Vertical and horizontal loads transmitted from the superstructure disperse rapidly from the top of a pier. Hence, the overall design of a pier is normally conducted on a meter strip basis, assuming a **uniform distribution** of axial and bending effects. The magnitude of the axial compressive stresses in a concrete pier is normally between 0.5～1.0 N/mm$^2$ under dead loading and it is unlikely to be more than 2 N/mm$^2$ under the most severe live load conditions. The degree of bending will depend upon the articulation of the deck and the length of the superstructure.

Reinforced concrete framed type of piers has been used in recent years. The main advantage in their use is due to reduced effective span lengths for girders on either side of the centre line of the pier leading to economy in the cost of superstructure.

Individual concrete columns are often used to support **footbridges** and bridge decks with high skew or greater height than the minimum **headroom clearance**. Columns may be vertical, inclined or even curved in shape to produce greater aesthetic appeal. A column section is normally required to resist **bi-axial** bending and significant axial loading. Concrete columns are therefore often circular or square, but **hexagonal** and **octagonal** sections are also common.

## Abutments

An abutment serves two principal functions. It is the substructure which supports one **terminus** of the superstructure of a bridge and, at some time, laterally supports the **embankment** which serves as an approach to the bridge. For a river bridge, the abutment also protects the embankment from scour of the stream. Bridge abutments can be made of masonry, **plain concrete** or reinforced concrete. Hence, an abutment combines the functions of a pier and a retaining wall.

Bridge abutments are prepared on the riverbank where the bridge end will rest. An abutment generally consists of the following three distinct structural elements: (1) the **breast wall**, which directly supports the dead and live loads of the superstructure, and retains the filling of the embankment in its **rear**; (2) the **wing walls**, which act as extensions of the breast wall in retaining the fill though not taking any loads from superstructures; and (3) the **back wall**, which is a small retaining wall just behind the **bridge seat**, preventing the flow of material from the fill on to the bridge seat.

One of the most common types of abutment is the gravity abutments with wing walls. It consists of a central pier supporting the bridge seat, and two wing walls to retain the fill. All three elements rest on a single footing. If the wing walls are at right angles to the pier, the structure is known as a U abutment. The wing walls of a U abutment are sometimes tied together to reduce their tendency to overturn.

The **spill-through** or **open abutment** is also widely used. It consists of two or more vertical columns carrying a beam that supports the bridge seat. The fill extends on its natural slope from the bottom of the beam through the openings between the columns. In its extreme form a spill-through abutment is no more than a row of piles driven through the fill and supporting a bridge seat. Another common variation is a simple pier with small wings near the top. The fill in this case spills around the abutment.

The design of an abutment consists in assuming preliminary dimensions depending on the type of the superstructure and foundation, and checking the stresses at the **sill** level. The front face of the breast wall should have a **batter** of not less than 1 in 25, preferably at 1 in 12. The rear batter is adjusted to get the width required to restrict the net pressures within the prescribed limits.

A bridge abutment may fail in several ways as below, and the final design should be checked to avoid these failures. The breast wall may fail by tensile cracks, crushing or shear. The wall may **tilt** forward due to excessive **overturning moment** due to earth pressure. The wall may slide forward due to earth pressure if the vertical forces are inadequate. Though the wall may be structurally strong, failures may occur along a curved surface by **rupture** of the soil due to inadequate **shear resistance**.

## Words and Phrases

abutment [ə'bʌtmənt] *n.* 桥台，桥墩，桥基
dimension [di'menʃən] *n.* 尺寸，度量，量纲
cellular ['seljulə] *adj.* 多孔的，格状的
trestle ['tresl] *n.* 支架，栈桥，高架桥
hammerhead ['hæməhed] *n.* 倒梯形，锤头

semicircular ['semi'sə:kjulə] *adj.* 半圆的
shuttering ['ʃʌtəriŋ] *n.* 模板(壳)
diaphragm ['daiəfræm] *n.* (横)隔板，阻隔
waterway ['wɔ:təwei] *n.* 航道，排水沟(渠)
footbridge ['futbridʒ] *n.* 人行桥
bi-axial [bai'æksiəl] *adj.* 双轴的，双向的
hexagonal [hek'sægənəl] *adj.* 六角形的，六边形的
octagonal [ɔk'tægənl] *adj.* 八边(角)形的；*n.*八边(角)形
terminus ['tə:minəs] *n.* 终点站，终点，边界，界限，极限
embankment [im'bæŋkmənt] *n.* 路堤，岸堤，堤
rear [riə] *n.* 后部，背
sill [sil] *n.* 底梁，底座，基础，底面，
batter['bætə] *n.* 倾斜，坡度，倾斜度
tilt [tilt] *n.* 倾斜，车篷；*vt.* & *vi.* (使)倾斜，斜置
rupture ['rʌptʃə] *n.* 破裂，断裂；*vt.* & *vi.*(使)破裂
end (intermediate) supports 端部(中间)支撑
multi-span bridge 多跨桥
lean (plain) concrete 素混凝土
bent cap 排架帽
uniform distribution 均匀分布
headroom clearance 净空高度
breast wall 胸(前)墙
wing wall 翼(侧)墙
back wall 背墙
bridge seat 桥梁支座
spill-through 穿通式的
open abutment 敞开式桥台
overturning moment 倾覆力矩
shear resistance 抗剪力



## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Gravity abutment consists of a central ________ supporting the bridge seat, and two ________ walls to retain the fill.

2. Piers can be solid, ________, trestle or ________ types. Substructure of bridge fall into two distinct categories: ________ supports and ________ supports.

3. Substructure of bridge fall into two distinct categorise; ________ supports and ________ supports.

4. In some recent designs, concrete hinges have been introduced between the top of columns and the ________ cap in order to avoid moments being transferred from deck to the ________.

Ⅱ. Translate the following passages from English into Chinese.

Common elements of the substructure of bridge are abutments (usually at the bridge ends) and piers (between the abutments). Piers and abutments often rest on separately constructed foundations such as concrete spread foundations or pile foundations, these foundations are part of the substructure. An abutment serves two principal functions. It supports the end of a bridge span, and it provides at least some lateral support for the soil or rock on which the roadway rests immediately adjacent to the bridge. Hence, an abutment combines the functions of a pier and a retaining wall. For typical forms of reinforced concrete abutments, the wing walls have been cantilevered without extending the base of breast wall for support, as would have been necessary for masonry abutment. The slope of the bottom edge of the wing should be such as to have this edge below the level of the revetment of the embankment.

The dimensions of the top of a pier shaft for a bridge are determined by practical considerations such as the magnitude of the bridge-shoe reactions, the distance required to provide for expansion of the superstructure, and the distance between trusses or girders. If the shaft extends through a body of water, its shape may be streamlined below high water to prevent eddy currents and scour.

## Section C Bridge Rehabilitation



In the last two decades, the rapid **deterioration** of bridge structures has become a serious technical and economical problem in many countries, including highly developed ones. Therefore, bridge rehabilitation has also become a very essential factor (sometimes even a decisive one) in contemporary bridge engineering.

The process of rehabilitating a deficient bridge can vary extensively depending on degree and the severity of the problems needing correction. The work can include a deck replacement and minor repair or can be an involved procedure including strengthening of critical members, replacing bearings and others. Strengthening techniques include **welding**, **plate bonding** and **external post-tensioning** which increase the stiffness of bridge decks. Replacement of elements has been used for deck slabs and beams, piers and columns.

The primary purpose of essential maintenance is to increase the **load carrying capacity** and the reason for the inadequate capacity is secondary. The selection of the maintenance method for repairs and prevention depends primarily on the cause of deterioration. If the reason is simply increased loading the maintenance can be limited to increasing the capacity, but if the reason is deterioration then maintenance must also include repairs and **preventative maintenance**.

The most common rehabilitation of a bridge is replacement of the deck or of the deteriorated portions of the deck. The most common deterioration is the result of **chloride ions** penetrating the concrete and consequent corrosion of the reinforcing steel. **De-icing** chemicals placed on the bridge deck are the primary source of chloride ions. The type and extent of deck restoration depends greatly on the chloride content and percentage of deck area contaminated. Often bridge decks with less than 1 lb of chloride per cubic yard at the rebar level are protected by overlaying with a

waterproofing membrane or low **slump** concrete. For bridge deck with greater than 2 lb of chloride per cubic yard of concrete at the **rebar** level, commonly called the critical salt concentration, most highway agencies remove the contaminated concrete to below the upper reinforcing steel, **sand blast** the steel, coat the rebars with an **epoxy** protection material, and place new concrete.

For bridge decks with extensive chloride contamination, **cathodic protection** and epoxy grouting are sometimes used. Complete replacement of bridge decks is normally recommended if more than 40 percent of the surface area of the deck is **contaminated**. Normally, the deck replacement incorporates coated rebars in the upper layer and a water-proofing membrane or low slump concrete-surfacing to protect the deck from early chloride contamination.

Deterioration of the reinforcing steel is caused by **corrosion** and can be prevented by actions taken at the time of construction and for a period after construction. Preventative techniques that can be applied at construction include the use of **epoxy coated mild steel**, **stainless steel** or **carbon or glass fiber reinforcement**, inhibitors, cathodic protection, **anti-carbonation coatings**, **silane** treatments and water-proofing membranes. All of these techniques, except the last three, directly protect the reinforcement against corrosion and to date, have been used only occasionally largely on grounds of cost. When corrosion of the reinforcement occurs it results in a loss of steel section and/or cracking, **spalling** and **delamination** of the concrete due to the stresses produced as a result of the low density of rust compared with density of the steel. Reinforcement corrosion repair methods have two main functions, to stop the corrosion and to repair the damaged concrete. There are a number of techniques available: concrete replacement; cathodic protection; **desalination**; re-**alkalization**.

A method of increasing the load-capacity, which is often easily accomplished, is the reduction of the dead load. In many older bridges, the **asphalt** overlays have built up until the dead load from this material is significant. In some cases, the capacity can be increased by simply removing excess overlay material. In other situations, the entire deck may be removed and replaced by a lighter weight decking material.

Rehabilitation of a bridge may include improvement of the geometry in the form of changing **vertical clearances**, widening of the structure, or improving horizontal or vertical alignment. A common form of bridge damage is vehicular collision damage resulting from vertical clearance restrictions. This form of damage is partially common when one or two bridges on a route have significantly less vertical clearance than the other structures. Renovation may be accomplished by reducing the depth of portals or by lowering the floor system to increase the vertical clearance. A thinner deck system may also provide some additional clearance.

The bearings, expansions, hangers, and similar devices associated with structural contraction and expansions frequently need rehabilitation. These devices often cease functioning properly as a result of corrosion. Usually, repair involves cleaning these devices and adjusting to the proper position. Many other rehabilitation techniques are available to correct deficiencies in bridge components but have not been discussed in this paper. These include cosmetic repairs as well as repairs needed to increase capacity and improve the structural integrity of the bridge.

Bridge inspection is now recognized as an essential part of the highway program. If the program is to remain effective, then damage, deterioration, and other defects must be addressed

through a continuing maintenance and rehabilitation program. The huge investment in the highway infrastructure will be **erased** quickly if proper maintenance and rehabilitation procedures are enforced and funded. Numerous government agencies and industry associations sponsor and conduct research to improve materials and construction techniques to extend the service life of bridge. A major goal is the development of lighter, stronger, more durable materials such as reformulated, high-performance concrete; fiber-reinforced, **polymer** composite materials to replace concrete for some components; epoxy coatings and electro-chemical protection systems to prevent corrosion of steel rebar; alternative synthetic reinforcing fibers; and faster, more accurate testing techniques.

## Words and Phrases

rehabilitation [ˈriː(h)əˌbiliˈteiʃən] *n.* 复原，修复，重建
deterioration [diˌtiəriəˈreiʃən] *n.* 退化，变质，恶化
welding [ˈweldiŋ] *n.* 焊接法，定位焊接；*adj.*焊接的
chloride [ˈklɔːraid] *n.* ［化］氯化物
ion [ˈaiən] *n.* 离子
de-ice [ˌdiːˈais] *vt.* 除去……上的冰，防止……上结冰，防冻
slump [slʌmp] *n.* 坍落度，坍塌；*vi.*坍塌，衰退
rebar [riˈbɑː] *n.* 钢筋(条)，螺纹钢筋
epoxy [eˈpɔksi] *adj.* 环氧的；*n.* 环氧树脂(胶)
contaminate [kənˈtæmineit] *vt.* 损害，污染
corrosion [kəˈrəuʒən] *n.* 腐蚀，受腐蚀的部位
silane [ˈsilein] *n.* ［化］硅烷
spall [spɔːl] *n.* (尤指岩石的)碎片，碎石；*vt.* & *vi.*弄碎，击碎(矿石)
delamination [diːˌlæmiˈneiʃən] *n.* 分层，分叶
desalination [diːˌsæliˈneiʃən] *n.* 减少盐分，脱盐作用
alkalization [ˌælkəlaiˈzeiʃən;-liˈz-] *n.* ［化］碱性化 *vt.*碱化
asphalt [ˈæsfælt] *n.* 沥青 *vt.*铺沥青
erase [iˈreiz] *vt.* 擦掉，抹去，清除
polymer [ˈpɔlimə] *n.* 聚合物(体)
plate bonding 贴板，粘接板
external post-tensioning 体外后张预应力
load carrying capacity 荷载承载力
preventative maintenance 预防性养护(检修，保养)
sand blast 喷砂(器)
cathodic protection 阴极防腐(保护)法
epoxy coated 环氧树脂涂盖
mild steel 软钢，低碳钢
stainless steel 不锈钢
carbon (glass) fiber reinforcement 碳(玻璃)纤维加强
anti-carbonation coating 抗碳酸化保护层
vertical clearance 竖向净空

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Rehabilitation of a bridge may include improvement of the ________ in the form of changing vertical clearances, widening of the ________, or improving horizontal or ________ alignment.

2. The selection of the maintenance method for repairs and prevention depends primarily on the cause of ________.

3. A major goal is the development of lighter, ________, more ________ materials.

4. The type and extent of deck restoration depends greatly on the ________ content and percentage of deck area contaminated.

5. Deterioration of the reinforcing steel is caused by ________ and can be prevented by actions taken at the time of construction and for a period after construction.

Ⅱ. Translate the following passages from English into Chinese.

Replacement of inadequate bridge railing, alteration of parapet and railing ends where these face oncoming traffic, protection with attenuators at ends of through girders or through trusses, in gore areas on structures, or in front of piers within the recovery zone (9 m, 30 feet from pavement edge) are all measures that should be considered in bridge rehabilitation plans.

In some cases, temporary patching and pothole repair is used on badly contaminated decks until the corrosion of the rebar or concrete deterioration renders the structure unsafe for legal load to cross the structure.

Desalination can be used to stop corrosion caused by chlorides and it works by migrating chloride ions towards and external anode and away from the reinforcing steel in an electric field; this process takes about 6 weeks. Re-alkalization stops corrosion caused by carbonation and it works by migrating sodium ions from an external anolyte into the concrete where in combination with the hydroxyl ions generated on the reinforcing steel due to the electric field, the alkalinity is raised to a level where the steel re-passivates. Concrete replacement can also be used to stop corrosion although this involves the removal of all the carbonated and chloride contaminated concrete even though it is physically sound.



# 参 考 译 文

## 第 8 章　桥 梁 工 程

Section A　桥梁

桥梁是人类征服空间的伟大象征，它能够跨越许多障碍，比如河流、湖泊、峡谷，为交通提供了道路。到目前为止，大多数桥梁的功能是承担汽车和铁路交通，但也有一些为行人所用，另外，桥梁也支持管道、槽或其他运输材料的渠道，比如输油管或者水渡槽等。

人类从远古时期就已经开始修建桥梁了。近千年来拱桥一直是桥梁的传统形式，由于其固有的外形，这类结构可以利用砖石作为它的材料。直到 19 世纪后期，混凝土才被用作建筑

材料。第一次把钢筋混凝土应用于桥梁结构的是 Hemmebique。同一时期 Jackson 和 Doehring 提出了预应力混凝土的概念，但是由于混凝土收缩和徐变造成的高预应力损失使得它的应用并不成功。直到 1926—1928 年间 Freyssinet 采用高强度钢筋有效地控制了预应力损失，预应力结构才被认为是可行的。预应力混凝土被广泛用于桥梁结构是在 1950 年以后了。随着更大强度以及更加抗锈蚀合金的发展，钢材在桥梁上的应用也更加广泛了。铝合金早在 1933 年就应用于桥梁结构了，它极大地降低了桥梁的自重，但是由于造价昂贵并没有被广泛使用。

桥梁的主要结构被称为上部结构和下部结构，这种划分方法用在这里只是为了方便起见，然而，在许多桥梁中这两者的界限是很不明显的。桥梁也可以分为上承式和下承式。上承式桥梁的车道位于支撑结构之上，也就是说，承担荷载的上部结构是位于道路以下的。而下承式桥梁的道路是横穿上部结构的。上承式结构是居于主导地位的。因为它外形简洁，能够为汽车驾驶员提供更好的视线范围，而且如果将来由于交通要求需要拓宽道路也比较容易实现。

作用于桥梁结构构件上的荷载一般由三部分组成：恒载、活载和偶然荷载。恒载主要指的是桥梁自重——通常也是最大的荷载。活载则包括通过桥梁的汽车荷载以及正常的环境因素所产生的，比如气温变化、降水和大风。偶然荷载是指除去正常气候条件以外的环境因素，例如突发的强风和地震等。以上三种荷载在桥梁设计时必须考虑。桥梁的设计要求收集大量的数据并且选择可行的方案。从这一观点出发，最终的选择就被限定在这些入围的桥梁设计中了。而切合实际的工作计划就要根据整个工程由开始到完成的全部资料进行全面的考虑。通过应用高等数学、电子计算机和试验模型等技术设计师们可以对静态和动态条件下的应力和应变进行精确的计算。每一个中长跨桥梁的设计师都试图设计出一个结构可以最大程度满足那些特殊位置下的条件，其结果往往是不同的设计师会设计出不同的结构类型，无论是就基本的设计原则还是设计细节而言。

以下内容就桥梁一般的类型进行简要的介绍：

**梁桥**

梁桥或许是最常见和最基本的桥梁。横跨小河的一块木头或者一根其他材料都是最简单形式的梁桥。这段材料就被称为梁——它直接搁置在水域的两侧，或者支撑在很重的基础之上也就是众所周知的柱。梁桥包括两个基本类型：板梁和箱梁。简支梁桥或者连续梁桥可以由木材、钢材、混凝土、预应力混凝土或其他材料所构成。

预制装配式预应力梁桥是常见的一类桥型，可以修建成为立交桥或者跨河桥。这类桥 19 世纪 50 年代后被广泛应用。预应力就是指在荷载施加之前给予混凝土的预压力，从而使整个混凝土梁截面处于受压状态或者低拉应力状态。因为混凝土抗压强度较高而抗拉强度很弱，这种操作产生了更加有效的混凝土截面。

**拱桥**

拱桥的优点就是造型美观优雅。拱桥可以用砖石等块材修建，它们受到压力的作用而结合得很紧密。因为建造拱桥对抗拉强度几乎是没有要求的。钢筋混凝土拱桥和钢拱桥都是非常轻的结构类型。结构的基本组成就是拱、桥面和一些位于拱与桥面之间的支撑构件。

拱根据不同的外形一般分为圆弧形、抛物线和悬链线拱。有关的节点可以固接或铰接。以下三种类型的拱被经常采用：无铰拱、双铰拱和三铰拱。拱桥的主要支撑结构是一个或多个弧形构件。拱桥所承担的恒载和活载通过弧形构件传递到桥墩或两端的支撑构件上。

由于简单而优雅的结构，拱桥已经成为典型的桥梁形式。

**悬臂桥**

为了解决持续增加的跨径问题，除了梁桥和拱桥外，可以选择的有悬臂桥和悬索桥。在

美国跨度最大的悬臂桥是 Commodore John Barry 桥。

悬臂桥是采用了悬臂结构的桥型，悬臂是一端支撑而另一端没有支撑的结构，就像跳水板。如果锚固牢固悬臂是强度很高的一种结构。它由三部分组成：边梁、悬臂和中梁。这种构造可以获得更长的跨径和更宽的净空。

对于小型人行桥，悬臂是一种简单的梁型。然而，设计用于公路或铁路交通的大型悬臂桥往往采用钢桁架结构或者是预应力混凝土箱梁结构。

在 20 世纪前半期，悬臂梁桥是一种非常普遍的桥梁形式。但目前，一些评论家认为，斜拉桥将由于更大的跨越能力而取代悬臂桥。

**悬索桥**

悬索桥应用于那些无法修筑中间墩台的大跨径或稍短一些跨径的桥梁结构。在当今使用的所有桥梁形式中，悬索桥具有最大的跨越能力。悬索桥主要的结构组成包括：柔性主缆、塔架、锚锭、吊杆、桥面板和加劲梁。一些原始的悬索桥使用藤或绳索作为缆索。

典型的悬索桥是连续梁结构，一个或多个主塔竖立在跨径中部的墩台之上。梁本身通常采用钢桁架或是箱梁，板梁的情况也不少见。在悬索桥的两端设置大型的锚锭结构用以固定缆索。如果悬索桥设计合理，比例得当，那么，毫无疑问在所有桥形中，它最美观的。

## Section B　桥梁的下部结构

桥梁支座以下基础以上的结构通常称其为下部结构。下部结构可以分为两个不同的类别：端部支撑和中间支撑。端部支撑通常称为桥台，而对于多跨桥的中间支撑一般称为桥墩。桥台和桥墩通常是现场混凝土浇筑而成，但是预制构件的应用可以加快施工进度。

**桥墩**

设计桥墩时必须特别注意，因为桥墩可能要承担由水流、浮冰或其他漂浮物产生的重荷。

桥墩的形状和形式在很大程度上取决于上部结构的形式、尺寸和规格以及桥墩所处的周边的环境。桥墩可以是实心式、空心式、排架式，倒梯形。跨河桥梁的实心桥墩或空心桥墩应当提供半削减水域，以适应水流的流向和减轻冲刷。其他设计，如钢筋混凝土框架形式也有应用。实心桥墩一般由圬工材料或大体积混凝土构成。对于暴露在外的部分容许使用石砌圬工结构，内部填注素混凝土。这样可以减少利用模板并且外表面也得以加强。空心式、排架式和倒梯形桥墩采用钢筋混凝土。空心桥墩能够节约混凝土用量，但是一般需要形式复杂的模板和用于加筋结构施工的额外劳动力。排架式桥墩由顶部带有排架帽的柱所组成。在最近很多的设计中为了避免产生由桥面向柱传递的弯矩，在柱顶和排架帽之间经常采用铰接。在立交桥和高架路中，高排架也用于连接柱与柱之间的横隔板。倒梯形桥墩具有细长的下部结构，通常适合高架路。当被用于跨河桥时，这类设计对航道的限制是最小的。

从上部结构传递下来的垂直荷载和水平荷载在桥墩顶部迅速扩散。因此，通常桥墩的整体设计是取单元宽度进行的，并且假定轴向力和挠度的影响都是均匀分布的。在恒载作用下，混凝土桥墩中轴向压应力的大小通常在 0.5～1.0 MPa 的范围内，并且在最不利活载条件的作用下，其值一般也不会超过 2 MPa。弯曲的程度取决于桥面板的联结情况和上部结构的长度。

在最近几年，钢筋混凝土排架式桥墩已经普遍应用。它的主要优势就是可以降低在桥墩中心线两侧梁的跨径，从而提高了上部结构造价的经济性。

单个混凝土墩柱常用来支撑人行桥和桥面板，这些桥面板斜度更大，高度也比最小净空高度高很多。为了使结构更加美观，柱可以是垂直的、倾斜的甚至是弯曲的。柱截面通常要求可以抵抗双向弯曲和很大的轴向荷载。因此混凝土柱通常为圆形或方形，六角形和八角形截面也比较普遍。

**桥台**

桥台有两个主要功能：它是下部结构，支撑桥梁上部结构的一个端部，有时它也为紧接桥梁的路堤提供横向支撑。对于跨河桥梁，桥台还要保护路堤免受水流冲刷。桥台可以由圬工材料、素混凝土或钢筋混凝土构成。因此，桥台综合了桥墩和挡土墙的功能。

桥台修筑在河岸上用以支撑桥梁端部。桥台一般由以下三个不同的结构构件组成：(1)前墙，直接承受上部结构的恒载和活载，抵抗其背部路堤的土压力；(2)侧墙，作为前墙的延伸部分，只抵抗背部土压力而不承担上部结构产生的荷载；(3)背墙，位于桥梁支座后部的小型挡土墙结构，以阻止路堤填土拥入到桥梁支座上来。

最常见的桥台形式是带有两个侧墙的重力式桥台。它由一个支撑桥梁支座的中心桥墩和两侧起挡土作用的侧墙组成。所有这三个部分都位于同一个基础之上。如果侧墙与桥墩呈直角，就是众所周知的 U 形桥台，其侧墙有时绑定在一起以防止结构倾覆。

穿通式或敞开式桥台的应用也比较普遍。它由两个或更多的支撑桥主梁的竖直柱所构成。填注材料按照其自然坡度从梁底部通过柱之间的空隙。穿通式桥台的极端形式是一排从填注材料中延伸出的支撑桥梁支座的桩。另外一种常见的形式就是简单的一个在顶部带有小型翼墙的桥墩，在这种情况下填注材料位于桥台周边。

桥台的设计包括：根据上部结构和基础的形式拟定初步尺寸，验算地基土压应力。胸墙前侧应该有不小于 1∶25 的坡度，最好是在 1∶12 左右。背部的坡度要进行适当的调整，以获取所需的宽度来限制静压力在规定的范围内。

桥台可能在以下几种情况下失效，而最终的设计必须保证能够避免这些失效。前墙可能由于张拉裂缝、冲击或是剪切而发生破坏。由于地震引起的过度的倾覆弯矩会造成墙体倾斜。如果垂直压力不足，在土压力的作用下墙体会产生滑移。即使墙体强度比较高，也有可能因为土体开裂造成抗剪不足导致墙体弯曲变形而失效。

Section C　桥梁修复

在过去的 20 年里，桥梁结构迅速地损坏在很多国家已经成为一个非常严重的技术和经济问题，包括许多发达国家，因此桥梁修复在当今的桥梁工程中也成为一个关键的问题(有时甚至是起决定作用)。

有缺陷桥梁的修复过程视其需要修复的严重程度有很大的区别。修复工作包括桥面板的置换，小型维修，以及对关键构件的加强处理，更换支座或其他构件等。补强技术包括焊接法、粘接板法和体外后张预应力法，这些方法都可以提高桥面板的刚度。构件置换技术已经应用于桥面板、梁、墩台和柱。

进行必要的维护的主要目的是提高承载能力，而承载力不足的原因是次要的。针对维修和防护方法的选择主要取决于损坏的原因，如果原因只是简单的荷载增加，那么加固维修就可以仅限定于提高结构的承载能力即可。但是如果原因是结构损坏，那么加固维修要包括修补和防护性养护。

最常见的桥梁修复是更换桥面板或者是桥面板损坏部分的替换。最常见的损坏是由于氯离子渗入到混凝土中，以及由此而造成的钢筋锈蚀。用于桥面除冰的化学品是氯离子的主要来源。桥面板的恢复情况很大程度上取决于氯盐的含量以及桥面损坏的比例大小。通常桥面板的钢筋中每立方米氯离子的含量应小于 1 磅[1 lb(磅)=0.45359237 kg]，而且桥面板受到覆盖其上的防水卷材和低坍塌混凝土的保护。对于桥面板的钢筋中每立方米氯离子的含量超过 2 磅的情况，通常被称为临界盐浓度，大多数的公路机构会去除位于上层钢筋下部被污染的混

凝土，喷砂打磨钢筋，给钢筋外部包裹环氧树脂保护膜之后，重新浇注混凝土。

针对桥面板普遍存在的被氯离子污染的问题，阴极保护法和环氧树脂灌浆法有时也被采用。如果 40%以上桥面受到损坏，一般推荐采用桥面全部更换的方法。通常，桥面板的替换包括：包裹上层钢筋、在混凝土表面铺设防水卷材或应用低坍塌混凝土以保护桥面早期免于受到氯离子的损坏。

由于腐蚀造成的钢筋损坏可以通过在施工中或竣工后采取相应措施予以避免。在施工中使用的保护技术包括环氧树脂包裹低碳钢，选用不锈钢、碳纤维或玻璃纤维加强，添加防锈蚀剂，采用阴极防腐，防碳酸化保护层，硅烷处治和防水薄膜。除了最后三项，其他措施都可直接用于防止钢筋腐蚀，到目前为止，主要由于价格的原因，这些措施仅仅只偶尔使用。当钢筋发生腐蚀时，会导致钢截面的损失和(或者)断裂，使混凝土产生剥落和分层，这也可能是由于铁锈的密度比刚的密度低而产生应力所引起。钢筋腐蚀修补方法具有两个功能：停止腐蚀和修复受损的混凝土。有许多可行的技术方法：混凝土替换法、阴极保护法、脱盐法以及再次碱化的方法。

还有一种提高承载力的方法很容易实现，就是降低恒载。在很多旧桥中由于沥青铺装层产生的恒载是可观的。在某些情况下，承载力的提高只需去除多余的铺装层，在其他情况下，整个桥面板都可以被去除，取而代之的是重量更轻的桥面材料。

桥梁修复还包括改进几何形式，可以通过改变竖向净空、结构加宽或者改善横向或纵向的线形。一个常见的桥梁损坏的现象是由于竖向净空受限而造成的车辆撞击破坏。当一座或两座桥梁跨越公路且其竖向净空远远小于其他结构时，这种形式的损坏尤为普遍。修复方法可以通过降低入口的深度或者减薄面层的厚度以增加竖向净空。更薄的桥面结构也可以提供一些额外的净空。

与结构相关的支座、伸缩缝、吊杆以及类似装置也需要进行频繁的维修。这些装置由于腐蚀常常造成功能的失效。通常，维修包括清除这些装置并且调整到适当的位置。还有许多其他修复技术被用于维修失效的桥梁构件，但在此就不具体讨论了。这些技术包括盖面维修，提高承载能力，对桥梁进行整体加固。

大桥检测现在已经公认为公路项目中非常重要的组成部分。如果该项目一直是有效的话，那么毁损、破坏或是瑕疵出现时必须做一个长期的维护和修复计划。如果合适的维护和修复工作能够得到很好的实施和资金投入，那么公路基础设施的高额投资会很快地被抵消掉。为了延长桥梁的使用寿命，许多政府机构和行业协会发起并进行了关于材料和施工技术改进的研究，一个主要的目标就是发展更轻更强更耐久的材料，比如再生高性能混凝土、加强纤维、聚合物复合材料，它们可以在某些构件上替代混凝土；另外还有保护钢筋免受锈蚀的环氧涂料和电化学保护系统；合成加强纤维，还有就是发展更快、更准确的检测技术。

## Grammar：专业英语的翻译技巧(Ⅴ)——词类转换

### Translation Skills of English for Professional Purpose Ⅴ—Word Formation

由于英汉两种语言在结构和表达习惯上都有很大差别，所以在我们英译汉时常遇到一些句子无法按原文的词性译成汉语；或是勉强译成汉语了，也不通顺，或根本不符合我们的说话习惯，不可能千篇一律的逐词对译。有时英语的名词可以译成汉语动词，而英语的动词可

以译成汉语的名词，如此等等，称之为词类转换。翻译中常用到的此类转换可分为四种：转译成动词，转译成名词，转译成形容词，其他词类互译。

1. 转译成动词

英语和汉语比较起来，汉语中动词用得比较多，这是一个特点，往往在英语句子中只用一个谓语动词，而在汉语中却可以几个动词或动词性结构连用。例如，在 He admires the President's stated decision to fight for the job. (他对总统声明为保住其职位而决心奋斗表示钦佩)中，英语的谓语动词只有 admires 一个词，其他用的是过去分词(stated)、动词派生名词(decision)、不定式(to fight)和介词(for)等。汉语没有词形变化，但可以几个动词连用。因此，英语中不少词类(尤其是名词、介词、形容词和副词)在汉译时往往可以转译成动词。

(1) 名词转译成动词。

英语中有很多动词派生成名词的词，含有动作意味的名词，加后缀-er 的名词，这时翻译时要适当选择其词性翻译。

F：Rockets have found application for the exploration of the universe.

译文：火箭已经用来探索宇宙。

(2) 形容词转译成动词。

英语中表示知觉、情欲、欲望等心理状态的形容词，在联系动词后作表语用时，往往译成汉语的动词。常见的有：anxious, aware, afraid, able, doubtful, careful,angry,certain, confident, cautious,concerned,glad, ashamed, ignorant, thankful, etc.

【例 1】 The fact that she was able to send a message was a hint.

她能够给我带个信儿这件事就是个暗示。

(3) 副词转译成动词。

【例 2】 As he ran out, he forgot to have his shoes on.

他跑出去时，忘记了穿鞋子。

(4) 介词转译成动词。

【例 3】 Many laboratories are developing medicines against AIDS.

许多实验室正在研制治疗艾滋病的药物。

2. 转译成名词

(1) 名词派生转用的动词。

英语中有很多由名词派生及名词转用的动词，而汉语中我们不易或无法找到相应的动词，这时候就要将其转译为汉语的名词了。

【例 4】 To them, he personified the absolute power.

在他们看来，他就是绝对权威的化身。

(2) 英语的被动句。

有些英语被动式句子中的动词，可以译成“受(遭)到……＋名词”、“予(加)以＋名词”这类结构。

【例 5】 Satellites, however, must be closely watched, for they are constantly being tugged at by the gravitational attraction of the sun, moon and earth.

由于经常受到太阳、月亮以及地球引力的影响，卫星活动必须加以密切的观察。

(3) 形容词转译成名词。

英语中有些形容词加上定冠词表示某一类的人，汉译时常译成名词。

【例 6】 They did their best to help the sick and the wounded.

他们尽了最大的努力帮助病号和伤员。

此外，根据情况还有些形容词可以译成名词。如：

【例 7】 Stevenson was eloquent and elegant—but soft.

史蒂文森有口才、有风度，但很软弱。

3. 转译成形容词

(1) 英语中还有很多名词是由形容词派生出来的，在汉译时往往直接译成形容词的意思更好，更贴切。

【例 8】 The pallor of her face indicates clearly how she was feeling the moment.

她苍白的脸色清楚地表明了她那时的情绪。

【例 9】 The security and warmth of the destroyer's sick bay were wonder.

驱逐舰的病室很安全也很温暖，好极了。

(2) 有些名词加不定冠词作表语时，往往可以转译成形容词。

【例 10】 The blockade was a success.

封锁很成功。

【例 11】 Independent thinking is an absolute necessity in study.

独立思考对学习是绝对必需的。

4. 其他词类互译

(1) 形容词转译为副词。

【例 12】 we have made a careful study of the properties of these chemical elements.

我们仔细研究了这些化学元素的特征。

(2) 副词转译为形容词。

【例 13】 It is a matter of common observation that gases are perfectly elastic.

众所周知，气体是完全弹性体。

(3) 英语代词译成汉语非代词。

【例 14】 The temperature of the hot body falls while that of the cold one rises.

热物体的温度下降而冷物体的温度上升。

(4) 名词转译为副词。

【例 15】 It is our great pleasure to note that our shipbuilding industry is developing vigorously.

我们很高兴地看到，我国的造船工业正在蓬勃发展。

# Chapter 9

# Structure Analysis and Computer Application

## Section A Structures

To construct is to put together structural elements to create a structure, a cohesive whole that meets previously-determined demands. The structural elements are linked to one another by means of **joints**. The structure is linked to its normally fixed environment through **supports**.

### Structural elements

As far as structural mechanics is concerned (strength and stiffness), one always tries to make the most efficient use of the specific properties of a limited number of **building blocks**, or structural elements. The way of modelling in structural mechanics allows one to distinguish the following four types of structural elements:

◆ Particle element

A particle element is a zero-dimensional structural element: all dimensions of the element are negligibly small with respect to those of other elements. The dimensions of the element play a subordinate role.

◆ Line element

A line element is a one-dimensional structural element: two of the dimensions of the element (those of the **cross-section**) are considerably smaller than the third dimension (the length). Line elements with a straight axis as known by a wide range of names, such as bar, beam, **joist**, **girder**, column, post and member. The **nomenclature** sometimes relates to the position of the line element in the structure: horizontal (beam, joist, girder) or vertical (column, post, **stay**). An (inflexible) curved line element is known as an arch. A line element without a particular shape is a **cable**: cables adapt to the loading.

◆ Surface element

A surface element is a two-dimensional structural element：one dimension of the element (the thickness) is considerably smaller than the other two dimensions (the length and width). In the two-dimensional model, all the properties of the element are assigned to a plane. With plates, the reference plane is a flat plane. With shells, the reference plane is curved. Plates are also given other names, such as **slab**, floor, wall and **disc**.

◆ Spatial element

A spatial element is a three-dimensional structural element: all the dimensions of the element

are of the same order of **magnitude** as those of other elements and are therefore not negligible.

## Joints between structural elements

Two bodies can be joined together in a wide variety of ways. For joints between structural elements, in the same plane, there are two kinds:

- **Hinged joints** (hinges);
- **Fixed joints** (entirely rigid or infinitely rigid joints).

In a hinged joint, or hinge, the joined parts can not translate with respect to one another, but can rotate freely with respect to one another. In a rigid joint, the joined parts cannot translate with respect to one another, nor can they rotate with respect to one another. The forces that the structural elements **exert** on one another in a joint are referred to as interaction forces or joint forces.

Hinges will always have a certain amount of resistance to rotation, even if only due to the occurrence of friction. If this resistance is limited, the joint can be idealized as a frictionless hinge. When the resistance to rotation in a joint is very large, the joint tends to be represented as infinitely stiff. The reality will always lie between these two extremes. **Spring joints** are joints in which the magnitude of the acting interaction forces is related to the deformation in the joint.

## Supports

Most structures are not free-floating, but are joined to a fixed environment. The joints between the structure and its fixed environment are called supports.

The interaction forces that act in the supports on the structure are known as support reactions. They act in the direction in which displacement of the structure is prevented. The forces that the structure exerts on the supports (for example on the foundation) are called support forces or support actions. The support forces are equal and opposite to the support reactions.

There are four types of supports:

- bar supports;
- roller supports;
- hinged supports;
- (fully)fixed supports.



## Planar structures

A spatial structure can often be viewed as a system of planar structures composed of line elements. It is therefore certainly worth investigating the properties of such planar structures in more detail. Based amongst other things on the nature of the joints and the external appearance, various types of planar structures can be distinguished.

***Planar trusses and frames.*** Planar **trusses** and **frames** are planar structures that are loaded in their plane (see Figure9.1).

The difference between a truss and a frame is determined by the nature of the joints in the connections.

- in a truss, the bars are joined together by hinges at all the connections;
- in frames, all the joints are fixed and entirely stiff.

The truss in Figure 9.1(a) is the model of a bridge. The open circles, which represent the hinged joints, are generally omitted as in a truss all the joints are by definition hinged. The structure in Figure 9.1(b) is a frame. You will recognise part of the building in Figure 9.2 here, with the vertical floor loading and the horizontal wind loading. Sometimes the stiffnesses of the joints are **accentuate**d by thickenings in the connections, but generally they are omitted. If there are also hinged joints in a frame, they have to be clearly depicted by means of open circles. This is the case in Figure 9.3, which could represent a building made of concrete, on which a steel floor was placed at a later stage.

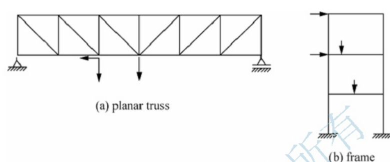



Fig. 9.1 A truss with by definition solely hinged joints and a frame with by definition exclusively rigid joints.

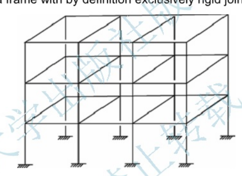


Fig. 9.2 An apartment building with the main load-bearing structure constructed of beams and columns.

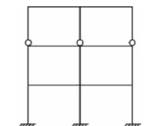


Fig. 9.3 If there are also hinged joints in a frame, these have to be clearly indicated by means of open circles

***Beam grillages.*** Beam grillages are planar structures that are loaded normal to their plane, see Figure 9.4. A beam grillage consists of two cooperative beam layers: beams and **girders**. The beams and girders are generally placed in two mutually perpendicular directions.

Beams grillages are often used as floor structures in bridges and buildings. Lock doors are also sometimes built as a system of beams and girders. A **facade** made of posts and girders(columns and beams), with **perpendicular** wind loading, can sometimes also be seen as a beam grillage.

Calculating the forces and deformations in a beam grillage is in fact a three-dimensional problem.

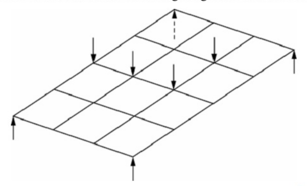


Fig. 9.4 A beam grillage

***Frames.*** Frames are planar, bent beams structures that are loaded in the plane of the structure. Such structures are often used to cover a space (**warehouse**, sports arena, and so forth).

Figure 9.5 shows a number of simple examples of frames. In Figure 9.6, both fixed supports have been replaced by hinged supports, so that the structure is now referred to as a two-hinged frame. If the structure with hinged supports itself consists of two parts joined by a hinge, this is referred to as a three-hinged frame (see Figure 9.7). If the beam structure is not bent but arched, then the structure in Figure 9.8 (a) is called a two-hinged arch, and the structure in Figure **Fig.**9.8 (b) is a three-hinged arch.



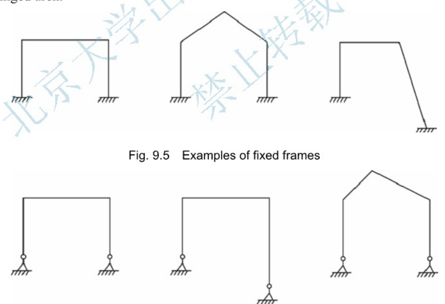


Fig. 9.5 Examples of fixed frames

Fig.9.6 Examples of two-hinged frames

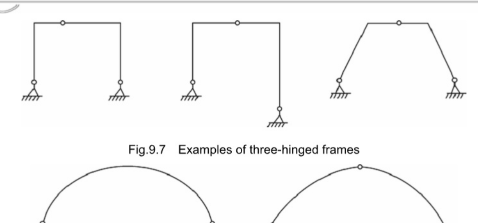


Fig.9.7　Examples of three-hinged frames

Fig.9.8　(a) A two-hinged arch and (b) a three-hinged arch

## Words and Phrases

joint [dʒɔint] *n.* 接头，接缝，接合点；*vt.*连接，接合；*adj.*连接的，联合的，共有的
support [səˈpɔːt] *vt.* 支撑，扶持，支持；*n.*支撑，支承，支撑物，支柱
building block 构件，结构单元
cross-section 横截面，断面，剖面图
girder [ˈgəːdə] *n.* 梁，大梁
stay [stei] *n.* 拉条，撑条，锁紧片
cable [ˈkeibl] *n.* 缆，钢绞线，钢索
slab [slæb] *n.* 板，平板
disc [disk] *n.* (圆，轮，研磨)盘，圆片[板，面，盘刀]，圆[甩油]环，(钢丝绳机的)轮圈
magnitude [ˈmægnitjuːd] *n.* 大小，值，量值，量级
hinged joint 铰节点
fixed joint 刚性节点
spring joint 弹性节点
planar structure 面状结构，平面结构
truss [trʌs] *vt.* 扎，缚，绑，用构架支撑；*n.*桁架，构架
frame [freim] *n.* 架构，骨架，结构；*vt.* 给……装框子，构筑，建造

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The nomenclature sometimes relates to the position of the line element in the structure: horizontal ________, ________, ________or vertical ________, ________, ________.

2. The open circles, ________represent the hinged joints, are generally omitted ________ in a truss all the joints are ________ definition hinged.

3. If the structure ________ hinged supports itself consists of two parts joined ________ a hinge, this is referred to ________ a three-hinged frame.

Ⅱ. Translate the following passages from English into Chinese.

In general, the standard procedure for analysis is a consideration of the linear elastic behaviour of the building. However, for analysis of earthquake-resistant buildings for which collapse is to be avoided, inelastic and nonlinear dynamic behaviour must be taken into account.

Although most structures are analyzed for linear elastic behaviour, certain extreme loading conditions, such as earthquake effects, require the analysis to be performed by taking into account the nonlinear mechanical properties of the material and the nonlinear geometrical changes caused by the varying load on the structure.

# Section B Computer-aided Design

## Overview

Computer-aided design (CAD) is the use of computer technology for the design of objects, real or virtual. The design of geometric models for object shapes, in particular, is often called computer-aided geometric design (CAGD).

However CAD often involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD often must convey also **symbolic** information such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

Current Computer-Aided Design software packages range from 2D **vector**-based drafting systems to 3D solid and surface modellers. Modern CAD packages can also frequently allow rotations in three dimensions, allowing viewing of a designed object from any desired angle, even from the inside looking out. Some CAD software is capable of dynamic mathematic modeling, in which case it may be marketed as CADD — computer-aided design and drafting.

CAD has become an especially important technology within the scope of computer-aided technologies, with benefits such as lower product development costs and a greatly shortened design cycle. CAD enables designers to lay out and develop work on screen, print it out and save it for future editing, saving time on their drawings.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, **prosthetics**, and many more. CAD is also widely used to produce computer **animation** for special effects in movies, advertising, technical manuals. The modern **ubiquity** and power of computers means that even perfume bottles and **shampoo dispensers** are designed using techniques unheard of by shipbuilders of 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and **discrete differential geometry**.

## Software technologies

Originally software for Computer-Aided Design systems was developed with computer languages such as Fortran, but with the advancement of object-oriented programming methods this

has radically changed. Typical modern parametric feature based modeller and freeform surface systems are built around a number of key C (programming language) modules with their own APIs. A CAD system can be seen as built up from the interaction of a graphical user **interface** (GUI) with NURBS geometry and/or boundary representation (B-rep) data via a geometric modeling **kernel**. A geometry constraint engine may also be employed to manage the associative relationships between geometry, such as wireframe geometry in a sketch or components in an assembly.

Unexpected capabilities of these associative relationships have led to a new form of **prototyping** called digital prototyping. In contrast to physical **prototypes**, which entail manufacturing time and material costs, digital prototypes allow for design **verification** and testing on screen, speeding time-to-market and decreasing costs. As technology evolves in this way, CAD has moved beyond a documentation tool (representing designs in graphical format) into a more robust designing tool that assists in the design process.

## Hardware and OS technologies

Today most Computer-Aided Design computers are Windows based PCs. Some CAD systems also run on one of the UNIX operating systems and with Linux. Some CAD systems such as QCad, NX or CATIA V5 provide multiplatform support including Windows, Linux, UNIX and Mac OS X.

Generally no special hardware is required with the possible exception of a good graphics card, depending on the CAD software used. However for complex product design, machines with high speed (and possibly multiple) CPUs and large amounts of RAM are recommended. CAD was an application that benefited from the installation of a numeric **coprocessor** especially in early personal computers. The human-machine interface is generally via a computer mouse but can also be via a pen and digitizing graphics tablet. Manipulation of the view of the model on the screen is also sometimes done with the use of a spacemouse/SpaceBall. Some systems also support stereoscopic glasses for viewing the 3D model.

## History

The beginnings of CAD can be traced to year 1957, when Dr. Patrick J. Hanratty developed PRONTO, the first commercial numerical-control programming system. In 1960, Ivan Sutherland MIT's Lincoln Laboratory created SKETCHPAD, which demonstrated the basic principles and feasibility of computer technical drawing.

***2D Time.*** The first CAD systems served as mere replacements of drawing boards. The design engineer still worked in 2D to create technical drawing consisting from 2D wireframe **primitives** (line, arc, B spline ...). Productivity of design increased, but many argue that only **marginally** due to overhead—design engineers had to learn how to use computers and CAD. Nevertheless modifications and revisions were easier, and over time CAD software and hardware became cheaper and affordable for mid size companies. CAD programs grew in functionality and user friendliness.

***3D Time.*** 3D wireframe features were developed in the beginning of the sixties, and in 1969 MAGI released Syntha Vision, first commercially available solid modeler program. Solid modeling further enhanced the 3D capabilities of CAD systems. NURBS, mathematical representation of freeform surfaces, appeared in 1989—first on Silicon Graphics workstations. In 1993 CAS Berlin

developed an interactive NURBS modeler for PCs, called NöRBS.

***Parametric design.*** In 1989 T-FLEX and later Pro/ENGINEER introduced CADs based on parametric engines. Parametric modeling means that the model is defined by parameters. A change of dimension values also changes the geometry of model, and vice versa. Parametric engines also work with geometrical constraints (for example "this must be parallel with that and in the middle of ...").

MCAD systems introduced the concept of constraints that enable you to define relations between parts in assembly. Designers started to use a **bottom-up** approach when parts are created first and then assembled together. Modeling is more **intuitive**, precise and later analysis, especially **kinematics** easier.

***Present.*** CAD / CAE / CAM systems are now widely accepted and used throughout the industry. These systems moved from costly workstations based mainly on UNIX to **off-the-shelf** PCs. 3D modeling has become a **norm**, and it can be found even in applications for the wider public, like 3D buildings modeling in Google Maps, house furnishing (IMSI Floorplan), or garden planning. Advanced analysis methods like FEM, flow simulations are an **ubiquitous** part of the design process.

## Future

The past of CAD has been full of unmet expectations. This continues. Some anticipate 3D modelling without flat screens or mouse pointers—a fully immersive 3D environment where modelling tools include special gloves and goggles. In the future, designing will be closer to sculpting than painting.

Up to now, 3D goggles cause **nausea**, immersive technologies are expensive and complex, and most designers prefer using a keyboard, stylus, and mouse.

While some of these optimistic predictions may come true, the more likely course is that the future changes will evolve in ways we do not see now. Still, some trends seem more likely to succeed and be widely adopted than others....

## Words and Phrases

symbolic [sim'bɔlik] *n.* 代号；*adj.* 象征的，符号的
vector ['vektə] *n.* 向量，矢量
prosthetics [prɔs'θetiks] *n.* 修复学，装补学(假肢，假眼，假牙)
animation [ˌæni'meiʃən] *n.* 活泼，生气；卡通制作，动画
ubiquity [juː'bikwəti] *n.* 到处存在，普遍存在
ubiquitous [juː'bikwitəs] *adj.* 到处存在的，普遍存在的
shampoo [ʃæm'puː] *n.* 洗头(洗发剂)；*vt.*洗发
dispenser [dis'pensə] *n.* 药剂师，配药员；分配器，分装机
discrete differential geometry 离散微分几何
interface ['intəfeis] *n.* 界面，接触面
kernel ['kəːnl] *n.* 核心，中心，精髓[计算机] 核心
prototyping ['prəutətaipiŋ] *n.* 原型机制造，样机研究
prototype ['prəutətaip] *n.* 原型，样机，典型，样板，模范，标准
verification [ˌverifi'keiʃən] *n.* 确认，查证，作证

coprocessor [ˈkrəuˌprəucesə] *n.* 协处理器
primitive [ˈprimitiv] *n.* 图元，基元
marginally [ˈmɑːdʒinəli] *adj.* 有限的；*adv.*在边上，边际地
parametric [ˌpærəˈmetrik] *adj.* 参数的
bottom-up 从下到上
intuitive [intjuːitiv] *adj.* 直觉的
kinematics [ˌkainiˈmætiks] *n.* 运动学
off-the-shelf 非专业化设计的；现成产品；位务变数
norm [nɔːm] *n.* 标准，规范
nausea [ˈnɔːsjə] *n.* 反胃，晕船，极度的不快

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. CAD has become an especially important technology ________ the scope of computer-aided technologies, ________ benefits such as lower product development costs and a greatly shortened design cycle.

2. In contrast ________ physical prototypes, ________ entail manufacturing time and material costs, digital prototypes allow for design verification and testing ________ screen, speeding time-to-market and decreasing costs.

3. These systems moved ________ costly workstations based mainly ________ UNIX ________ off-the-shelf PCs.

Ⅱ.Translate the following passages from English into Chinese.

Accordingly，they have tried to use the computer's huge memory capacity，fast processing speed，and user-friendly interactive graphics capabilities to automate and tie together otherwise cumbersome and separate engineering or production tasks，thus reducing the time and cost of product development and production.

That is，the result of the synthesis subprocess is a conceptual design of the prospective product in the form of a sketch or a layout drawing that shows the relationships among the various product components.



# Section C Fundamentals of Finite Element Analysis

## Introduction

The finite element method (FEM), sometimes referred to as finite element analysis (FEA), is a computational technique used to obtain approximate solutions of boundary value problems in engineering. Simply stated, a boundary value problem is a mathematical problem in which one or more dependent **variables** must satisfy a differential equation everywhere within a known **domain** of independent variables and satisfy specific conditions on the boundary of the domain. Boundary value problems are also sometimes called field problems.

The field variables are the dependent variables of interest governed by the differential equation. The boundary conditions are the specified values of the field variables (or related variables such as derivatives) on the boundaries of the field.

Depending on the type of physical problem being analyzed, the field variables may include physical displacement, temperature, heat **flux**, and fluid **velocity** to name only a few.

## How the FEM Works

To summarize in general terms how the finite element method works we list main steps of the finite element solution procedure below.

***Discretize the continuum.*** The first step is to divide a solution region into finite elements. The finite element mesh is typically generated by a **preprocessor** program. The description of **mesh** consists of several arrays main of which are nodal coordinates and element connectivities.

***Select interpolation functions.*** Interpolation functions are used to **interpolate** the field variables over the element. Often, **polynomials** are selected as interpolation functions. The degree of the polynomial depends on the number of nodes assigned to the element.

***Find the element properties.*** The **matrix** equation for the finite element should be established which relates the nodal values of the unknown function to other parameters. For this task different approaches can be used; the most convenient are: the variational approach and the Galerkin method.

***Assemble the element equations.*** To find the global equation system for the whole solution region we must assemble all the element equations. In other words we must combine local element equations for all elements used for **discretization**. Element connectivities are used for the assembly process. Before solution, boundary conditions (which are not accounted in element equations) should be imposed.

***Solve the global equation system.*** The finite element global equation system is typically **sparse**, **symmetric** and positive definite. Direct and **iterative** methods can be used for solution. The nodal values of the sought function are produced as a result of the solution.

***Compute additional results.*** In many cases we need to calculate additional parameters. For example, in mechanical problems strains and stresses are of interest in addition to displacements, which are obtained after solution of the global equation system.

## A General Procedure For Finite Element Analysis

Certain steps in formulating a finite element analysis of a physical problem are common to all such analyses, whether structural, heat transfer, fluid flow, or some other problem. These steps are embodied in commercial finite element software packages. We do not necessarily refer to the steps explicitly in the following chapters. The steps are described as follows.

***Preprocessing.*** The preprocessing step is, quite generally, described as defining the model and includes

Define the geometric domain of the problem.

Define the element type(s) to be used.

Define the material properties of the elements.

Define the geometric properties of the elements (length, area, and the like).

Define the element connectivities (mesh the model).

Define the physical constraints (boundary conditions).

Define the loadings.

***Solution.*** During the solution phase, finite element software assembles the governing algebraic equations in **matrix** form and computes the unknown values of the primary field variable(s). The computed values are then used by back substitution to compute additional, derived variables, such as reaction forces, element stresses, and heat flow.

As it is not uncommon for a finite element model to be represented by tens of thousands of equations, special solution techniques are used to reduce data storage requirements and computation time. For static, linear problems, a wave front solver, based on Gauss elimination (Appendix C), is commonly used.

***Postprocessing.*** Analysis and evaluation of the solution results is referred to as postprocessing.

Postprocessor software contains sophisticated routines used for sorting, printing, and **plotting** selected results from a finite element solution. Examples of operations that can be accomplished include

Sort element stresses in order of magnitude.

Check equilibrium.

Calculate factors of safety.

Plot deformed structural shape.

Animate dynamic model behavior.

Produce color-coded temperature plots.

While solution data can be manipulated many ways in postprocessing, the most important objective is to apply sound engineering judgment in determining whether the solution results are physically reasonable.

## Assess the accuracy of a finite element solution

If we know the exact solution, we would not be applying the finite element method! So how do we assess the accuracy of a finite element solution for a problem with an unknown solution?

A person using the finite element analysis technique must examine the solution analytically in terms of (1) numerical **convergence**, (2)reasonableness (Does the result make sense?), (3)whether the physical laws of the problem are satisfied (Is the structure in **equilibrium**? Does the heat output balance with the heat input?), and (4) whether the **discontinuities** in value of derived variables across element boundaries are reasonable. Many such questions must be posed and examined prior to accepting the results of a finite element analysis as representative of a correct solution useful for design purposes.

## A Brief History

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the “stiffness and deflection of complex structures”.

By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

## Words and Phrases

variable [ˈvεəriəbl] *n.* 易变的事物，可变物，变量；*adj.* 可变的，易变的，变量的
domain [dəuˈmein] *n.* 领域，领土，产业，范围，定义域
flux [flʌks] *n.* 流出，涨潮，变迁；*vi.*熔化，流出；*vt.* 使熔融
velocity [viˈlɔsiti] *n.* 速度，迅速，速率
discretize [ˈdiskriːtaiz] *vt.* 使离散
continuum [kənˈtinjuəm] *n.* 连续统一体，连续体，连续区，连续介质
preprocessor [priːˈprəusesə(r)] *n.* 预处理程序；预处理器
postprocessing [ˌpəustˌprəusesiŋ] *n.* 后处理，后加工；预处理，预加工
mesh [meʃ] *n.* 网孔，网丝，网眼，网状物，圈套，陷阱，啮合
interpolation [inˌtəːpəuˈleiʃən] *n.* 插入[值]，内插；插值法，内插[推]法
interpolate [inˈtəːpəuleit] *vt.&vi.* 窜改(文稿，书等)，插入，增添(字句等)，插值，内插，内推
polynomial [ˌpɔliˈnəumjəl] *adj.* 多项式的，多词学名的；*n.*多项式，多词学名
matrix [ˈmeitriks] *n.* 模型，矩阵
discretization [disˌkriːtiˈzeiʃən] *n.* 离散化
sparse [spɑːs] *adj.* 稀疏的，稀稀落落的，稀薄的
symmetric [siˈmetrik] *adj.* 对称的，均匀的，匀称的
iterative [ˈitərətiv] *adj.* 反复的，重复的，迭代的，迭接的
plot [plɔt] *n.* 小块土地，地区图，图，阴谋，情节；*vt.* 划分，绘制，密谋
convergence [kənˈvɜːdʒəns] *n.* 集中，收敛
equilibrium [ˌiːkwiˈlibriəm] *n.* 平衡，平静，均衡
discontinuity [ˈdisˌkɔntiˈnju(ː)iti] *n.* 间断，中断，不连续，间断性

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. ________ it is not uncommon ________ a finite element model to be represented ________ tens of thousands of equations, special solution techniques are used to reduce data storage requirements and computation time.

2. If we know the exact ________, we would not be applying the finite element method! So how do we assess the ________ of a finite element solution for a problem with an ________ solution?

Ⅱ.Translate the following passages from English into Chinese.

Certain steps in formulating a finite element analysis of a physical problem are common to all such analyses, whether structural, heat transfer, fluid flow, or some other problem.

Many such questions must be posed and examined prior to accepting the results of a finite element analysis as representative of a correct solution useful for design purposes.

# 参考译文

## 第9章 结构分析与计算机应用

Section A 结构

建造就是把结构单元拼装到一起，从而形成满足预定要求的具有连贯整体的一个结构。结构单元相互之间是通过节点来联系的。通常结构通过支撑与外界环境相联系。

**结构单元**

就结构力学而言，我们常常要有效利用有限数量的结构构件或结构单元。结构力学正确建模方法是要求我们区分以下四种结构单元：

◆ 点单元

点单元是一个零维结构单元，单元所有方向的尺寸相对于其他单元尺寸来讲，小得可以忽略不计。单元尺寸在结构分析中不是主要考虑因素。

◆ 线单元

线单元是一维结构单元，单元两个方向(截面上)的尺寸与第三维(长度)方向尺寸相比小得多。具有直线轴线的线单元我们知道的很多，例如杆、梁、小梁、大梁、柱、支柱以及杆件。单元名称有时与其在结构中的位置有关，如水平杆件(梁、小梁、大梁)或垂直杆件(柱、支柱、撑杆)。不可弯曲的弧形单元称为拱。没有特定形状的单元是索(其形状依所加外载而定)。

◆ 面单元

面单元是二维结构单元，单元一个方向(厚度方向)的尺寸与另两个方向(长度方向和宽度方向)相比小得多。在二维模型中，单元所有的性质都可以放在一个假定的参考面中来考虑。例如，平板的参考面是一平面，壳的参考面是一曲面。平板也有其他名称，如楼板、地板、墙和圆形板等。

◆ 空间单元

空间单元是三维结构单元，单元所有方向的尺寸同其他单元尺寸是同数量级的，因此单元各方向尺寸不可忽略。

**结构单元间节点**

两个物体能够通过多种方式相连，同一平面内结构单元间的节点有两种：铰节点(铰)和刚性节点(完全刚性或刚性较大的节点)。

铰节点(或铰)中，被铰接的部分之间不能相对移动，但是可以自由地相对转动。刚性节点中，被连接部分相互间既不能相对移动，也不能相对转动。结构单元在节点上相互作用力称为内力或节点力。由于摩擦力等因素的存在，铰在转动过程中将或多或少受到阻力的影响。若这种阻力较小，则可以把其理想化为无摩擦力的情况；若这种阻力较大，则可以把其视为无穷刚度构件。实际结构中使用的铰节点通常介于上述两种极端情况之间。弹性铰节点是指那些作用力与其变形相关的铰节点。

**支承**

大部分结构不是自由悬浮的，而是与固定的外部物体相连，连接结构与固定体的节点称为支承。作用在结构上支承中相互作用力称为支承反力，沿着阻碍结构位移的方向作用。结构作用在支承上的力(如作用在基础上)称为支承力或支承反力。支承力与支承反力大小相等方向相反。

有四种支承类型：杆支承、滚动支承、铰链支承和固定支承。

**平面结构**

空间结构常被视为由线单元构成的平面结构体系。因此，应该对这种平面结构的特性有更加细致地了解。根据铰节点的性质以及结构外部表现形式的不同，我们可以划分出许多类型的平面结构。

**平面桁架和框架** 平面桁架和框架是位于平面内的平面结构(见图 9.1)。

桁架和框架间的区别在于连接节点的性质。

在桁架结构中，所有杆件都是被铰节点连接在一起的；框架结构中，所有的节点都是固定和完全刚性的。

图 9.1(a)中的桁架是一座桥梁的力学模型，由于在桁架结构中节点都被定义为铰节点，所以代表铰节点的圆圈常被省略掉。图 9.1(b)中的结构是框架，你可能认出这是图 9.2 中结构的一部分，受到竖向楼面荷载和水平方向风荷载的作用。有时通过加厚连接件的厚度来增强节点的刚度，但常常忽略不计。如果在框架中有铰节点的话，必须清晰地用圆圈表示出来。图 9.3 中表示的在混凝土结构上后安装的钢楼面就是这种情况。

**格栅梁** 格栅梁荷载作用在其平面上的平面结构，见图 9.4。格栅梁由两组相互作用的梁组成，即主次梁。主次梁位置相互垂直。

格栅梁常用于桥梁和建筑物中的楼面结构。水闸门也通常是格栅梁结构体系。由柱和梁组成的立面，受到正面风载荷作用时，有时也被视为格栅梁。

实际上，计算格栅梁的受力和变形是三维问题。

**框架** 框架是平面的、弯曲梁结构，荷载作用在结构平面内。这种结构常常用在封闭空间上(如仓库、运动场等)。图 9.5 显示了一组框架结构的简单例子，图 9.6 中，所有的固定支承均被替代成铰支承，这时结构成为两铰框架。如果有铰支承的结构本身由铰连接的两部分组成，这种结构成为三铰框架(见图 9.7)。如果非弯曲梁结构呈拱形，则图 9.8(a)中的结构为两铰拱，9.8(b)中的结构为三铰拱。

Section B 计算机辅助设计

**概述**

计算机辅助设计(CAD)是使用计算机技术进行实体设计、仿真或模拟。通常把用于物体形状的几何模型的设计称为计算机辅助几何设计(CAGD)。

然而 CAD 不止仅限于形状的设计。因为在手册中规定，技术工程图的绘制、CAD 的输出必须也要按照特定应用的约定来传达物体的符号信息，如材料、工艺、大小和允许误差。

目前计算机辅助设计软件程序包内容涵盖了基于二维矢量的绘图系统到三维实体和曲面的建模。当前的 CAD 软件也能使所建模型沿三个方向任意旋转，可以从不同的角度观察物体，甚至能够由内向外看。一些 CAD 软件能够进行动态数学建模，在这种情况下 CAD 可以被当作 CADD(计算机辅助设计及绘图)使用。

CAD 在计算机辅助技术方面已经成为一种特别重要的技术，它的应用有利于降低产品的开发成本和显著缩短设计周期。CAD 能够使设计者在计算机屏幕上进行设计和开发，为了以后编辑方便，可将其打印和存储起来，节省了设计师绘图的时间。

CAD 是一项重要的工业艺术，在许多应用中被广泛使用，包括汽车、造船、航空航天工业、工业与建筑设计、修复学等。CAD 也广泛应用在电影中特殊效果的计算机动画制作上，同时也可用于制作广告和技术指导手册。当今计算机的普及和强大的功能，意味着即使香水

瓶、洗发水分配器这样的产品的设计，采用的是20世纪60年代造船专家从未听说过的技术。由于其巨大的经济重要性，计算机辅助设计已成为研究计算几何、计算机图形学(硬件和软件)以及离散微分几何的主要驱动力。

**软件技术**

起初的计算机辅助设计系统软件是随着计算机语言发展起来的，例如Fortran语言。但是随着面向对象程序设计方法的进步，计算机辅助设计系统已经发生了根本性的改变。在一些关键的附有API的C语言模块的基础上，建立了基于建模软件和自由曲面系统的典型的现代参数特征。通过一种带有NURBS几何图形的用户界面(FUI)和/或通过几何建模核心的边界代表(B-rep)值的交互，建立了CAD系统。也可以用几何约束求解引擎处理几何图形之间的关联关系，如线框几何图形的绘制或部件的装配。

这些关联关系意想不到的能力导致了一种被称为数字样机的新型原型制造的出现。与物理原型不同，数字样机允许在屏幕上进行设计的验证和测试，从而加速市场投放时间和降低成本，而物理原型制造则需要制造时间和材料成本。随着技术以这样的速度发展，CAD的作用已不仅限于文件工具(以图形方式表现设计)，而且成为一个有助于设计过程的强有力的设计工具。

**硬件和操作系统技术**

目前大多数用于计算机辅助设计的计算机是基于PCs的Windows操作系统。一些CAD系统在某种UNIX操作系统和Linux系统中也可运行。一些CAD系统例如QCad, NX或CATIA V5提供了包括Windows, Linux, UNIX和Mac OS X多个支持平台。

在使用CAD软件时，除了要求高质量的显卡，一般来说不需要专门的硬件。不过在设计复杂产品时，推荐使用配有高速运转的CPU和大容量随机存取存储器的计算机。CAD是一种应用软件，受益于数字协处理器的安装，尤其是在早期的个人计算机中。人机界面一般是通过计算机鼠标但是也能够通过笔和数字绘图板。屏幕上观察到的模型的操作有时也可用spacemouse/SpaceBall处理。有些系统也支持立体眼镜观看三维模型。

**历史**

CAD的出现可以追溯到1957年，Patrick J. Hanratty博士开发出了最早的商业数控程序系统——PRONTO。1960年，Ivan Sutherland麻省理工学院林肯实验室开发出SKETCHPAD，证实了计算机技术制图的基本原理及可行性。

**二维时代** 第一代CAD系统仅仅取代了绘图板。设计工程师仍然以二维方式创建由二维线框单元(直线、弧线、曲线等)构成的技术图形。设计效率提高了，但基于设计师必须学习如何使用计算机和CAD的费用是非常有限的，所以引起了较多争议。不过，由于修改变得越来越容易，而且CAD软硬件越来越便宜，对于中等规模的公司也可以买得起。CAD程序的多功能性和用户友好性越来越强。

**三维时代** 三维线框特征出现于20世纪60年代，1969年MAGI推出了首款商用实体模型程序Syntha Vision，实体建模进一步增强了CAD系统的三维功能。硅谷图形工作站首先于1989年制作出表示数学自由曲面的NURBS(非均匀样条曲面)。1993年CAS Berlin开发出一款计算机互动曲面建模程序，称为NöRBS。

**参数设计** 1989年T-FLEX同后来的Pro/ENGINEER推出了基于参数引擎的CAD。参数建模就是通过参数来定义模型。尺寸数值的变化也会引起几何模型的改变，反之亦然。参数引擎也会对几何约束起作用(比如，这个必须平行而且居中……)

MCAD系统引入了使你能够定义组装部分之间相互关系的约束思想。当部件形成然后组

装在一起时，设计师开始使用自下而上的组装方法。建模更加直观和准确，而且以后的运动分析也更加容易。

**现状** 目前 CAD/CAE/CAM 系统在全行业内被广泛接受和使用。这些系统由主要基于 UNIX 的费用较高的工作站转移到现成的个人计算机平台中。三维建模已经成为标准，甚至为广大公众所使用，像谷歌地图、房屋装修或园林规划中三维建筑的建模。FEM、流体仿真等高级分析方法普遍存在于设计过程中。

**未来发展**

CAD 过去始终没有达到令人满足的期望值，还将继续完善。一些人期待着不通过平板显示器和鼠标指针实现三维模型的建模——一个完全身临其境的三维环境，建模工具包括特殊的手套和护目镜。将来，设计将更接近于雕塑，而非绘画。

到目前，三维立体眼镜引起眩晕，身临其境的技术比较复杂且成本较高，大多数设计师仍偏好于使用键盘、触针和鼠标。

而其中一些乐观的预言可能成为现实，更可能的进程是未来的变化将会以我们目前看不到的方式发展。然而某些发展趋势似乎更有可能成为现实并且被广泛接受。

## Section C 有限元分析基础

**引言**

有限单元法又称有限单元分析，是用来求解工程中已知边界条件问题的近似解的计算方法。简单地说：已知边界条件的问题就是一个或多个自变量满足一个在已知领域里的多变量微分方程，并且其主要边界要满足一定条件的数学问题。已知边界条件的问题也被称为边值问题。

研究变量是微分方程中的主要独立变量。边界条件就是这一物理结构的自变量(或相关变量)在边界上需满足的特定值。

依据分析问题的类型，变量可能包括位移、温度、热通量和流体速度等。

**有限元法的基本原理**

为了简单表述一下有限元的主要工作原理，我们将有限元求解过程中的主要步骤进行了以下罗列。

**连续体的离散**。第一步是将求解区域划分成有限的单元。有限单元网格在前处理程序中产生。有限元网格包还有节点坐标和单元连接的信息。

**插值函数的选择**。插值函数是用来对单元上的自变量进行插值。常用的为多项式插值函数，多项式的阶数主要由单元的节点数目来确定。

**寻找单元特性**。应当建立联系未知函数节点值和其他参数关系的有限单元矩阵方程，有限单元矩阵方程的建立可以采用不同的方法，最方便的方法是变量法和伽辽金法。

**单元矩阵方程的集成**。为了寻找整个求解领域的整体方程系统，我们必须组装所有单元方程。换句话说就是，我们必须将所有离散单元的局部单元矩阵进行组合。单元的连接信息在组装过程中被使用。在求解之前，应该施加边界条件(这不包括在单元矩阵方程中)。

**整体方程系统的求解**。有限单元的整体方程系统一般是稀疏、对称和正定的。直接和迭代方法可在求解中被应用。未知函数的节点值为方程的求解结果。

**附加结果的计算**。在许多问题中，我们需要计算附加参数。比如，在力学问题中的应力和应变就是与位移所联系的附加参数，这两个值只能在整体计算求解结束后才能获得。

**有限元分析的一般程序**

采用有限单元法求解物理问题(无论是结构问题、热传导问题、流体或其他一些问题)时都有一些特定的步骤。这些步骤都被嵌入商用有限元软件包中。我们没有必要在下文中将各步骤进行详细的说明，仅对各步骤进行简单的概述。

**前处理**。前处理确切地说就是定义模型，其步骤包括：

定义分析问题的几何关系；

定义所需的单元类型；

定义单元的材料特性；

定义单元的几何特性(长度、面积)；

定义单元的连接特性(网格划分)；

定义物理约束(边界条件)；

定义荷载。

**求解**。在求解阶段，有限元软件将几何方程集成为矩阵的形式，并计算主要变量中的未知量，然后将计算结果反代入求解附加变量，比如支座反力，单元应力和热流等。

因为有限元模型通常包括上万个方程，所以，利用一些特殊的求解技术来降低数据的存储要求和计算时间。对于静力线性问题，通常采用基于高斯消元法的波前求解器来求解。

**后处理程序**。后处理求解器是用来分析和评估计算结果。

后处理器软件包括一些尖端的程序用来分类、打印和绘制从有限元计算结果中选中的部分结果。在后处理中可以完成的实例有：

依据单元应力值进行分类排序；

平衡性检验；

计算安全系数；

绘制变形后的结构形式；

模型的动力学动画模拟；

产生温度云纹图。

当计算结果可以在后处理的许多方面被利用时，那么最重要的目标就是应用合理的工程判断决定计算结果是否可靠。

**评价有限元计算结果的精确性**

如果我们知道精确解，我们将不用有限单元法！我们如何才能评估一个没有精确求解方法问题的有限元计算结果的精确性？

应用有限元分析技术必须检查求解分析的项目有：(1)数值收敛性；(2)合理性(结果产生了影响吗？)；(3)问题的物理准则是否满足(结构是否处于平衡状态？热量的输入输出是否平衡？)；(4)单元自变量值的不连续性是否合理。许多这样的问题必须在我们接受有限元计算结果之前提出并进行核实。

**有限元发展的历史**

有限元分析首先于1943年由柯朗提出，他利用数值分析里兹法和变量积分最小化获得了振动系统的近似解。不久，M.J.Turner、R.W.Clough、H.C.Martin 和 L.J.Topp 于 1956 年发表的“复杂结构的刚度和变形”这篇论文中，建立了数值分析更加广泛的定义。

直到1970年代早期，有限元分析方法仍受限于昂贵的大型计算机，一般仅在航空学、汽车制造、国防工程和核工业领域使用。随着计算机价格的快速下降和计算机计算能力的显著提高，有限元分析方法计算精度显著提高。现在超级计算机能对各种参数进行精确的计算。

## Grammar：专业英语的翻译技巧(Ⅵ)——成分转换

## Translation Skills of English for Professional Purpose Ⅵ—Sentence Elements Transformation

英译汉时，有时为了通顺，往往需要将原文的某一句子成分转译成另一成分，进行句子成分的转换。

1. 非主语译成主语

(1) 介词的宾语译为主语。

【例 1】 High-quality machines of various types are produced in our country.

我国生产各种类型的优质机器。

(2) 动词宾语译为主语

这种宾语在意义上跟主语有比较密切的联系，通常是主语的某一部分或某一属性。

【例 2】 An automobile must have a brake with high efficiency.

汽车的制动必须高度有效。

(3) 表语译成主语。

【例 3】 Ice is not so dense as water and therefore it floats.

冰的密度小于水，因此能浮在水面上。

(4) 定语译为主语。

【例 4】 The average temperature in summer is as high as 35℃. One can not be pleasured living in that place.

夏天的平均温度高达 35℃，生活在那里是不可能舒服的。

(5) 谓语译为主语。

【例 5】 When a material is stressed beyond the elastic limit a permanent deformation results.

当一种材料的应力超过弹性极限时，就会产生永久变形。

(6) 宾语译为主语。

【例 6】 His father flew into rage with what he had done.

他的所作所为让他的父亲大发雷霆。

2. 非谓语译成谓语

(1) 定语译为谓语。

【例 7】 Solids have a shape independent of the container.

固体的形状与容器无关。

(2) 主语译为谓语。

【例 8】 There is a need for improvement in your study habits.

你的学习习惯需要改进。

(3) 表语译为谓语。

英语中的某些形容词、副词、介词、名词接介词短语等在句中做表语时，通常可译成动词谓语。

【例 9】 The new rule is applicable to foreigners.

这一项新规定适用于外国人。

3. 非宾语译成宾语

(1) 主语译成宾语。

【例 10】 Much progress has been made in computer science in less than a century.

不到一个世纪，计算机科学取得了很大进步。

(2) 状语译为宾语。

【例 11】 Materials to be used for structural purpose are chosen so as to behave elastically in environmental condition.

结构上用的材料必须得选择对环境条件适应性很强的。

4. 非定语译为定语

(1) 主语译为定语。

【例 12】 The satellite system uses this device in varied forms.

卫星系统上的这种装置有各种不同的形状。

(2) 状语译成定语。

【例 13】 In this world, things are complicated and are decided by many factors.

世界上的事情是复杂的，是由各方面的因素决定的。

(3) 宾语译为定语。

【例 14】 His speech on the current international economic situation produces the profound influence on research work of that subject.

他的关于目前国际经济形式的讲话，对我们的研究工作产生了很大的影响。

5. 非状语译为状语

(1) 主语译为状语。

【例 15】 After that, his youthful indifference to studies and his unwillingness to think of a non-sports career caught up with him.

在那之后，由于他年轻时候对学习毫不关心，以及不愿意考虑与运动无关的事情，他终于得到了报应。

(2) 定语译为状语。

【例 16】 We need a dialogue that prevents any single issue form holding the entire relationship captive.

我们需要对话来防止任何有碍两国关系的事情发生。

# Chapter 10

## Soil Mechanics and Foundation

### Section A Characteristics of Soils

#### Physical property

Soil is usually composed of three phases: solid, liquid, and gas. The mechanical properties of soils depend directly on the interactions of these phases with each other and with applied potentials (e.g., stress, **hydraulic head**, electrical potential, and temperature difference).

The solid phase of soils contains various amounts of **crystalline** clay and non-clay minerals, noncrystalline clay material, organic matter, and **precipitated** salts. These minerals are commonly formed by atoms of elements such as oxygen, silicon, hydrogen, and aluminum, organized in various crystalline forms. These elements along with calcium, sodium, potassium, magnesium, and carbon comprise over 99% of the solid mass of soils. Although, the amount of non-clay material is greater than that of clay and organic material, the latter have a greater influence in the behavior of soils. Solid particles are classified by size as clay, **silt**, sand, gravel, **cobbles**, or **boulders**.

The liquid phase in soils is commonly composed of water containing various types and amounts of dissolved **electrolytes**. Organic compounds, both **soluble** and **immiscible** are present in soils from chemical **spills**, leaking wastes, and contaminated groundwater.

The gas phase, in partially **saturated** soils, is usually air, although organic gases may be present in zones of high biological activity or in chemically contaminated soils.

Soil mineralogy controls the size, shape, and physical and chemical properties of soil particles and thus its load-carrying ability and compressibility.

Soil, like any other engineering material, **distorts** when placed under a load. This **distortion** is of two kinds—shearing, or sliding, distortion and compression. In general, soils cannot withstand **tension**. In some situations the particles can be cemented together and a small amount of tension may be withstood, but not for long periods.

#### Effective stress

The concept of effective stress is one of Karl Terzaghi's most important contributions to soil mechanics. It is a measure of the stress on the soil skeleton (the collection of particles in contact with each other), and determines the ability of soil to resist **shear stress**. It cannot be measured in itself, but must be calculated from the difference between two parameters that can be measured or estimated with reasonable accuracy.

Effective stress ($\sigma'$) on a plane within a soil mass is the difference between total stress ($\sigma$)

and **pore** water pressure ($u$):

$$\sigma' = \sigma - u$$

The total stress $\sigma$ is equal to the **overburden** pressure or stress, which is made up of the weight of soil vertically above the plane, together with any forces acting on the soil surface (e.g. the weight of a structure). Total stress increases with increasing depth in proportion to the density of the overlying soil.

The pore water pressure $u$ is the pressure of the water on that plane in the soil, and is most commonly calculated as the **hydrostatic** pressure. For stability calculations in conditions of dynamic flow (under sheet piling, beneath a dam toe, or within a slope, for instance), $u$ must be estimated from a flow net. In the situation of a horizontal water table pore water pressure increases linearly with increasing depth below it.

## Shear strength

Most problems in **geotechnics**, e.g. bearing capacity of shallow and deep foundations, slope stability, retaining wall design, **penetration** resistance, soil **liquefaction** etc., are affected by the soil shear strength. Analytical and numerical analyses use values of shear strength for solving these engineering problems.

Shearing strength in soils is the result of the resistance to movement at interparticle contacts, due to particle interlocking, physical bonds formed across the contact areas (resulting from surface atoms sharing electrons at interparticle contacts), and chemical bonds.

The stress-strain relationship of soils, and therefore the shearing strength, is affected by:

- soil composition (basic soil material): mineralogy, grain size and grain size distribution, shape of particles, pore fluid type and content, ions on grain and in pore fluid.
- state (initial): State can be described by terms such as: loose, dense, overconsolidated, normally consolidated, stiff, soft, contractive, **dilative**, etc.
- structure: Structure of soils is described by terms such as: undisturbed, disturbed, remolded, compacted, cemented; **flocculent**, **honey-combed**, single-grained; **flocculated**, **deflocculated**; **stratified**, layered, **laminated**; **isotropic** and **anisotropic**.
- Loading conditions: Effective stress path—drained, undrained, and type of loading — magnitude, rate (static, dynamic), and time history (monotonic, cyclic).

## Consolidation

Consolidation is a process by which soils decrease in volume. It occurs when stress is applied to a soil that causes the soil particles to pack together more tightly, therefore reducing volume. When this occurs in a soil that is saturated with water, water will be squeezed out of the soil. The magnitude of consolidation can be predicted by many different methods. In the Classical Method, developed by Karl Terzaghi, soils are tested with an oedometer test to determine their compression index. This can be used to predict the amount of consolidation.

When stress is removed from a consolidated soil, the soil will rebound, regaining some of the

volume it had lost in the consolidation process. If the stress is reapplied, the soil will consolidate again along a recompression curve, defined by the recompression index. The soil which had its load removed is considered to be overconsolidated. This is the case for soils which have previously had glaciers on them. The highest stress that it has been subjected to is termed the preconsolidation stress. A soil which is currently experiencing its highest stress is said to be normally consolidated.

## Lateral earth pressure

Lateral earth stress theory is used to estimate the amount of stress soil that can exert perpendicular to gravity. This is the stress exerted on **retaining walls**. A lateral earth stress coefficient, $K$, is defined as the ratio of lateral (horizontal) stress to vertical stress for **cohesionless** soils ($K=\sigma_h/\sigma_v$). There are three coefficients: at-rest, active, and passive. At-rest stress is the lateral stress in the ground before any disturbance takes place. The active stress state is reached when a wall moves away from the soil under the influence of lateral stress, and results from shear failure due to reduction of lateral stress. The passive stress state is reached when a wall is pushed into the soil far enough to cause shear failure within the mass due to increase of lateral stress. There are many theories for estimating lateral earth stress; some are empirically based, and some are analytically derived.

## Bearing capacity

The bearing capacity of soil is the average contact stress between a foundation and the soil which will cause shear failure in the soil. Allowable bearing stress is the bearing capacity divided by a factor of safety. Sometimes, on soft soil sites, large settlements may occur under loaded foundations without actual shear failure occurring; in such cases, the allowable bearing stress is determined with regard to the maximum allowable settlement.

Three modes of failure are possible in soil: general shear failure, local shear failure, and **punching** shear failure.



## Words and Phrases

hydraulic [haiˈdrɔːlik] *adj.* 水力的；水力学的；液压的，水压的；水工的
hydraulic head 水头，水压头，水力压头，静压头，液压头
crystalline [ˈkristəlain] *adj.* 水晶的，结晶(体)的；透明的，清晰的
precipitate [priˈsipiteit] *vt.* 使沉淀(出)，淀析，析出；(使)凝结；降(水)
silt [silt] *n.* 淤泥；粉粒；粉砂；粉土
cobble [ˈkɔbl] *n.* 圆石，鹅卵石，粗砾；*v.* 铺鹅卵石
boulder [ˈbəuldə] *n.* 大圆石
electrolyte [iˈlektrəulait] *n.* 电解物，电解质，电解液
soluble [ˈsɔljubl] *adj.* 可溶解的
immiscible [iˈmisəbl] *adj.* 不能混合的，不融洽的
spill [spil] *n.* 溢出，流；*v.* 溢出，洒，使……流出
saturate [ˈsætʃəreit] *vt.* 使浸透，使渗透，使湿透，使饱和；使充满

distort [dis'tɔːt] *v.* 扭曲
distortion [dis'tɔːʃən] *n.* 扭曲，变形，曲解
tension ['tenʃən] *n.* 紧张；张力，拉力
effective stress 有效应力
shear stress 切变应力，剪应力，切应力，黏性摩擦应力
overburden [ˌəuvə'bəːdn] 覆盖层；表土
pore [pɔː] *n.* 毛[细，微，气]孔，孔隙
hydrostatic [haidrə'stætiks] *adj.* 流体静力学的，流体静压力的
geotechnics [dʒiːəu'tekniks] *n.* 土工学，地质技术学，地质工学
penetration [peni'treiʃən] *n.* 渗透，贯穿，穿透(深)度，渗透性
liquefaction [ˌlikwi'fækʃən] *n.* 液化(作用)
dilative [dai'leitiv] *adj.* 膨胀的，膨胀性的,有扩张作用的
flocculent ['flɔkjulənt] *adj.* 丛毛状的，柔毛状的，覆以绒毛的
honey-combed *adj.* 蜂窝状的
flocculate ['flɔkjuleit] *vt.* 絮凝；*n.* 絮凝物
deflocculate [diː'flɔkjuleit] *vt.* 反絮凝(散凝，反团聚)
stratified ['strætifaid] *v.* 分层；*adj.*成层的
laminated ['læmineitid] *adj.* 薄板的
isotropic [aisə'trɔpik] *adj.* 等方性的；各向同性的
anisotropic [ænˌaisə'trɔpik] *adj.* 各向异性的(非均质)
retaining wall 挡墙，挡土墙，护壁
cohesionless [kəu'hiːʒənlis] *adj.* 非黏结性的
punch [pʌntʃ] *n.* 打洞器，钻孔机，冲压机，冲床；*vt.*开洞，冲压冲孔

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The liquid phase________soils is commonly composed ________water containing various types ________ amounts of dissolved electrolytes.

2. It is a measure of the stress ________ the soil skeleton (the collection of particles in contact ________ each other), and determines the ability of soil _______resist shear stress.

3. Three modes of failure are possible in soil: ________ shear failure, ________ shear failure, and ________ shear failure.

Ⅱ. Translate the following passages from English into Chinese.

Compressibility is an important soil characteristic because of the possibility of compacting the soil by rolling, tamping, vibration, or other means, such increasing its density and load-bearing strength.

In cohesive soils the voids are very often completely saturated with water which in itself is nearly incompressible and therefore compression of the soil can only take place by the water moving out of the voids thus allowing settlement of the particles.

# Section B Foundations on Slopes

## Introduction

The design of foundation for structures on or **adjacent** to slopes must take into account the interaction between the structure and the slope.

Two **criteria** must be considered:

(1) the influence of the adjacent slope on the bearing capacity and settlement of the foundation, and

(2) the effect the foundation will have on the stability of the slope.

The first criterion recognises that there can be a significant reduction in bearing capacity (both horizontally and vertically) due to an adjacent slope (Vesic, 1975; Poulos, 1976; Schmidt, 1977) and the second criterion is important because the stability of a slope can be affected by excavation for the construction of foundations on or adjacent to the slope, the load imposed by foundations on or above the slope, or the temporary or permanent change in groundwater **regime** caused by construction of the foundation.

Typical foundation types in Hong Kong are spread footings, **caissons** (hand-dug and machine bored) and piles (**percussion**, bored, **precast** and **cast-in-place**). Spread footings and hand-dug caissons are the most common because heavy machinery is not required for construction, the operation of which is difficult on steep hillsides. Shallow foundation (spread footings) are used for light loads, and deeper foundations (piles) are used where the bearing **stratum** is at depth or where the stabillity of the slope would be impaired by any additional load from the foundation.



## Shallow foundations

Bearing capacity and settlement

The **ultimate bearing capacity** of a shallow foundation on a slope is lower than that for the same footing on level ground. A general expression for the ultimate bearing capacity of such foundations is reproduced from Geoguide 1 (Geotechnical Control Office, 1982) to which reference should be made:

(1) for guidance on the particular problem of estimating the bearing capacity of a foundation set-back from the **crest** of a slope, and

(2) for a discussion of other factors that can influence bearing capacity.

Where shallow foundations are constructed at more than one level on a slope, the foundations at the higher level may impose additional loading on the lower ones. This additional loading must be taken into account in the design.

In general, bearing capacity calculations do not **allow for** the fact that the soil forming the slope is already under stress, and so it is important to assess the overall stability of the slope under the influence of the loaded foundation. However, an acceptable **factor of safety against slope failure** obtained from a stability analysis that includes the influence of foundation loads, does not necessarily mean that the foundation is acceptable in terms of settlement.

Slope Stability

As a general rule, the stability of a slope affected by foundations should be checked if the slope

angle is greater than Φ'/2 (Vesic, 1975). Where this is so, the foundation can be considered as an equivalent line load or a **surcharge** imposing horizontal and vertical loads and incorporated into the stability analysis.

The **backfilling** to a foundation may be poor, and so the stability analysis should consider the possibility of a tension crack forming on the upslope-edge of the foundation.

For shallow foundations on or above rock slopes, the stability analysis should take into account potential instability due to adversely orientated **discontinuities**. The analytical methods of Hoek & Rray (1981) are useful in this respect.

The stability of a slope can be impaired by excavation for the construction of shallow foundations on or adjacent to the slope and the demolition of structures supporting the toe of the slope. Both these effects should be considered during the analysis. In order to minimise the short term instability of a slope, excavations should be as small as possible and should be properly **shored**.

## Deep Foundations

Lateral Loads

The horizontal stresses in a soil slope vary throughout the slope and, for deep foundations, the horizontal loading on the upslope side of the foundation is larger than on the downslope side. However, in a slope that has an acceptable factor of safety against failure, the difference in horizontal load is negligible (Schmidt,1977) and need not be considered during the design of most deep foundations.

However, high lateral loading can be transferred to foundations in situations where there is significant ground movement (i.e. where the slope above or below the foundation fails or where the slope in front of the foundation is excavated) or where there is only a small ground movement (i.e. creep) but where the foundation is very stiff.

Various methods of analysis are available for the analysis of single piles subjected to lateral loading due to ground movement. Wang & Yen (1974) and Ito & Davis (1977) use limiting equilibrium methods and suggest ways in which arching between closely-spaced piles can be considered. Poulos & Davis (1980) use finite difference methods; these, however, are very dependent on the correct definition of the stress-strain characteristics of the soil layers surrounding the piles (De Beer,1977).

Where possible, lateral loads on deep foundations should be prevented. This can be achieved by either:

(1) **stabilising** potentially unstable slopes before construction of the foundation, or

(2) by the provision of an **annular** sleeve around the foundation.

An annular sleeve is a space of sufficient width between the foundation and the surrounding soil so that both can move without interaction. The space, which can be air filled or can contain a suitable compressible material, must be wide enough to accommodate the ground movements expected and the deflection of the foundation itself.

For air-filled spaces, when a **lining** has to be used to support the soil, the lining must prevent the **ingress** of groundwater or surface water into the space and must prevent the space filling up with soil. The plug at the top of the air-gap between the lining, and the foundation should be designed so that there is no load transmitted through it.

For spaces that are filled with a compressible material, the design width should take into

account the compressibility of the material itself, especially as a result of the placement of **wet concrete** during construction.

In such circumstances, it may be appropriate to install the **annulus** eccentrically around the foundation with the centre of the annulus upslope of the centre of the foundation.

Slope Stability

Deep foundation can adversely affect the stability of slopes:

(1) by transmitting vertical or horizontal loads to the slope,

(2) by the removal of support during the excavation for construction of the foundation, or

(3) by the temporary or permanent change in the groundwater regime caused by the foundation.

To prevent the transmission of vertical loads onto a slope, the founding depth for a deep foundation should be below any potential failure plane within the slope. To prevent the transmission of horizontal loads, an annular sleeve should be provided. In this case, the annulus may be installed eccentrically around the foundation, but with the centre of the annulus downslope of the centre of the foundation. Where these measures are not possible and loads from the foundation are likely be transmitted to the slope, the stability of the slope under the influence of these loads should be assessed. However, this assessment is not easy as the methods usually adopted for stability analysis (limit equilibrium methods) are not compatible with those used to evaluate soil pressures (elastic methods).

When caissons or piles are closely spaced, there may be a reduction in overall **permeability** that would result in a rise in the groundwater level upslope of the foundation (Pope ＆ Ho, 1982). This possibility must be considered in the design, and any assumptions made should be checked by the installation and monitoring of **piezometers** after the foundation is in place.

Piles and caissons can be used to support slopes, and methods for their design in these situations are given by Gould (1970) and Fukuoka (1977).

## Words and phrases

adjacent [ə'dʒeisənt] *adj.* 接近的，附近的，毗连的，相邻的
criteria [krai'tiəriə] *n.* 标准
regime [rei'ʒi:m] *n.* 状态，方式
caisson ['keisən] *n.* 沉箱
percussion [pə:'kʌʃən] *n.* 冲击，撞击，碰击
precast ['pri:'kɑ:st] *vt.* 现浇制；*adj.*预制(的)，预浇铸(的)
cast-in-place 现浇
stratum ['streitəm] *n.* 层，地层，阶层
ultimate bearing capacity 极限承载力
crest [krest] *n.* 顶，山顶，浪峰，最高水位
allow for 考虑
factor of safety against failure 抗破坏安全系数
surcharge [sə:'tʃɑ:dʒ] *n.* 超载，负荷过重，过度的负担，过度的充电
backfilling *n.*回填
discontinuity [ˌdiskɔnti'nju(:)iti] *n.* 中断，间断，突变性，突变点
shore [ʃɔ:,ʃɔə] *n.* (房屋、树木等的)支柱，斜撑柱

stabilise [ˈsteibilaiz] *v.* (使)稳定，(使)安定，(使)坚固
annular [ˈænjulə] *adj.* 环的，环形的
lining [lainiŋ] *n.* 衬，衬套，套筒，衬垫，隔板
ingress [ˈingres] *n.* 进入，入口
wet concrete 塑性混凝土
annulus [ˈænjuləs] *n.* 环，环形物，环轮，环状空间，环形套筒
permeability [ˌpəːmiəˈbiliti] *n.* 透过性，可透[渗]性，渗透(性，度，率)
piezometer [ˌpaiəˈzɔmitə] *n.* 流压计，水压计，压力计，压强计

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The second criterion is important ________ the stability of a slope can be affected by excavation ________ the construction _______ foundations on or adjacent to the slope, the load imposed ________ foundations on or ________ the slope, or the temporary or permanent change in groundwater regime caused by construction of the foundation.

2. To prevent the transmission of vertical loads ________ a slope, the founding depth ________ a deep foundation should be below any potential failure plane ________ the slope.

Ⅱ. Translate the following passages from English into Chinese.

The main problem in the design of the foundations of a multi-storey building under which the soil settles is to keep the total settlement of the building within reasonable limits, but specially to see that the relative settlement from one column to the next is not great.

In practice, limiting equilibrium methods are used in the analysis of slope stability. It is considered that failure is on the point of occurring along an assumed or a known failure surface. The shear strength required to maintain a condition of limiting equilibrium is compared with the available shear strength of the soil，giving the average factor of safety along the failure surface.



# Section C Introduction to Pile Foundations

## Pile foundations

**Pile** foundations are the part of a structure used to carry and transfer the load of the structure to the bearing ground located at some depth below ground surface. The main components of the foundation are the pile **cap** and the piles. Piles are long and slender members which transfer the load to deeper soil or rock of high bearing capacity avoiding shallow soil of low bearing capacity. The main types of materials used for piles are wood, steel and concrete. Piles made from these materials are driven, drilled or **jacked** into the ground and connected to pile caps. Depending upon type of soil, pile material and load transmitting characteristic piles are classified accordingly. In the following section we learn about classifications and functions of piles.

## Function of piles

As with other types of foundations, the purpose of a pile foundations is to transmit a

foundation load to a solid ground and to resist vertical, lateral and uplift load.

A structure can be founded on piles if the soil immediately beneath its base does not have adequate bearing capacity. If the results of site investigation show that the shallow soil is unstable and weak or if the **magnitude** of the estimated settlement is not acceptable a pile foundation may become considered. Further, a cost estimate may indicate that a pile foundation may be cheaper than any other compared ground improvement costs.

In the cases of heavy constructions, it is likely that the bearing capacity of the shallow soil will not be satisfactory, and the construction should be built on pile foundations. Piles can also be used in normal ground conditions to resist horizontal loads. Piles are a convenient method of foundation for works over water, such as jetties or bridge piers.

## Classification of piles

Classification of piles with respect to load transmission and functional behaviour:

- **End bearing piles** (point bearing piles);
- Friction piles (cohesion piles );
- Combination of friction and cohesion piles.

End bearing piles transfer their load on to a firm **stratum** located at a considerable depth below the base of the structure and they derive most of their carrying capacity from the **penetration resistance** of the soil at the toe of the pile (see Fig. 10.1). The pile behaves as an ordinary column and should be designed as such. Even in weak soil a pile will not fail by buckling and this effect need only be considered if part of the pile is unsupported, i.e. if it is in either air or water. Load is transmitted to the soil through friction or cohesion. But sometimes, the soil surrounding the pile may adhere to the surface of the pile and causes "Negative Skin Friction" on the pile. This, sometimes have considerable effect on the capacity of the pile. Negative skin friction is caused by the drainage of the ground water and consolidation of the soil. The founding depth of the pile is influenced by the results of the site investigate on and soil test.

Carrying capacity of friction or cohesion piles is derived mainly from the adhesion or friction of the soil in contact with the shaft of the pile (see Fig. 10.2).

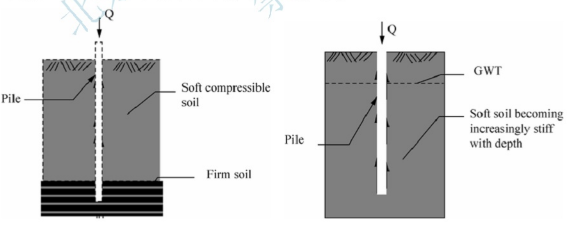



Fig.10.1 End bearing piles

Fig.10.2 Friction or cohesion pile

Cohesion piles transmit most of their load to the soil through skin friction. This process of

driving such piles close to each other in groups greatly reduces the **porosity** and **compressibility** of the soil within and around the groups. Therefore piles of this category are sometimes called **compaction piles**. During the process of driving the pile into the ground, the soil becomes moulded and, as a result loses some of its strength. Therefore the pile is not able to transfer the exact amount of load which it is intended to immediately after it has been driven. Usually, the soil regains some of its strength three to five months after it has been driven.

Friction piles also transfer their load to the ground through skin friction. The process of driving such piles does not compact the soil appreciably. These types of pile foundations are commonly known as floating pile foundations.

An extension of the end bearing pile when the **bearing stratum** is not hard, such as a **firm clay**. The pile is driven far enough into the lower material to develop adequate frictional resistance. A farther variation of the end bearing pile is piles with enlarged bearing areas. This is achieved by forcing a bulb of concrete into the soft stratum immediately above the firm layer to give an enlarged base. A similar effect is produced with **bored piles** by forming a large cone or bell at the bottom with a special **reaming** tool. Bored piles which are provided with a bell have a high tensile strength and can be used as **tension piles**.

Classification of pile with respect to type of material:

- Timber;
- Concrete;
- Steel;
- Composite piles.

***Timber piles.*** Used from earliest record time and still used for permanent works in regions where timber is plentiful. Timber is most suitable for long cohesion piling and piling beneath embankments. The timber should be in a good condition and should not have been attacked by insects. For timber piles of length less than 14 meters, the diameter of the tip should be greater than 150 mm. If the length is greater than 18 meters a tip with a diameter of 125 mm is acceptable. It is essential that the timber is driven in the right direction and should not be driven into firm ground. As this can easily damage the pile. Keeping the timber below the ground water level will protect the timber against decay and putrefaction. To protect and strengthen the tip of the pile, timber piles can be provided with toe cover. **Pressure creosoting** is the usual method of protecting timber piles.

***Concrete pile.*** **Pre cast** concrete piles or **prefabricated** concrete piles: Usually of square (see Fig.10.3(b)), triangle, circle or octagonal section, they are produced in short length in one metre intervals between 3 and 13 meters. They are pre-casted so that they can be easily connected together in order to reach to the required length (Fig.10.3(a)) . This will not decrease the design load capacity. Reinforcement is necessary within the pile to help withstand both handling and driving stresses. Prestressed concrete piles are also used and are becoming more popular than the ordinary precast as less reinforcement is required .

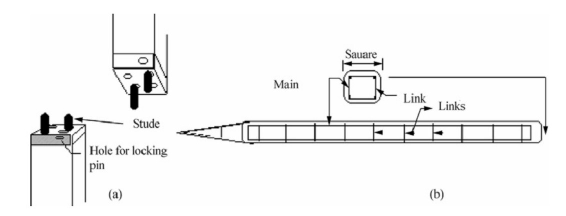



Fig.10.3 (a) concrete pile connecting detail. (b) squared pre-cast concrete pile

***Steel piles.*** Steel/ Iron piles are suitable for handling and driving in long lengths. Their relatively small cross-sectional area combined with their high strength makes penetration easier in firm soil. They can be easily cut off or joined by welding. If the pile is driven into a soil with low pH value, then there is a risk of corrosion, but risk of corrosion is not as great as one might think. Usually **tar** coating or **cathodic protection** can be employed in permanent works.

It is common to allow for an amount of corrosion in design by simply over dimensioning the cross-sectional area of the steel pile. In this way the corrosion process can be prolonged up to 50 years. Normally the speed of corrosion is 0.2～0.5 mm/year and, in design, this value can be taken as 1mm/year.

***Composite piles.*** Combination of different materials in the same of pile. As indicated earlier, part of a timber pile which is installed above ground water could be vulnerable to insect attack and decay. To avoid this, concrete or steel pile is used above the ground water level, whilst wood pile is installed under the ground water level.

## Words and Phrases

cap [kæp] *n.* 柱头，承台
jack [dʒæk] *n.* 插座，千斤顶；*vt.* 抬起，扛举，增加，提高
magnitude [ˈmægnitjuːd] *n.* 巨大，广大，重大，大小，强度
end bearing pile 端承桩
friction pile 摩擦桩
cohesion [kəuˈhiːʒən] *n.* 结合，凝聚，附着，内聚力
stratum [ˈstreitəm] *n.* 层，地层，阶层
penetration [ˌpeniˈtreiʃən] *n.* 穿透，渗透，穿透能力，穿透深度
resistance [riˈzistəns] *n.* 抵抗，反抗，抵抗力，抗性，抵制，阻力
porosity [pɔːˈrɔsiti] *n.* 多孔，空隙
compressibility [kəmˌpresiˈbiliti] *n.* 压缩性
compaction pile 密实桩，压实桩
bearing stratum 持力层；承重层
firm clay 硬黏土

bored pile 填充桩，螺旋钻孔桩
ream [riːm] *vt.* 扩大，挖通，挤出
tension pile 受拉桩，拉力桩
creosote [ˈkriəsəut] *n.* 杂芬油，木馏油，碳酸；*v.* 用木馏油处理
pressure creosoting 杂酚油加压浸渍，压注油浸防腐法
prefabricated 预制的
tar [tɑː] *n.* 焦油，柏油，沥青；*vt.* 涂焦油于，用焦油覆盖
cathodic [kəˈθɔdik] *adj.* 阴极的
cathodic protection 阴极保护，阴极防蚀法，阴极防蚀

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Piles are long and slender members ________ transfer the load to deeper soil or rock ________ high bearing capacity________ shallow soil of low bearing capacity.

2. This process of driving such piles ________ to each other in groups greatly ________ the porosity and compressibility of the ________ within and around the groups.

3. They are pre-casted ________ that they can be easily connected together in order to reach to the ________ length.

Ⅱ. Translate the following passages from English into Chinese.

There modern piledriving methods are: driven piles, where a prefabricated pile is driven into hard rock, providing a firm base; driven and cast piles, where the vibrator drives a steel tube into the ground, it is reinforced by steel grid and withdrawn after concrete is cast into it; and bored and cast piles, where a hole is drilled and a concrete mixture is cast directly into the hole.

The sizes of footings are determined by dividing the loads to be imposed at the base of the footings by the allowable bearing pressure which can be imposed on the soil or rock of the earth.




### 第 10 章　土力学与地基基础

Section A　土的特征

**物理性质**

土通常由三相组成：固相、液相和气相。土的力学性质依赖于这三相间的相互作用以及其他因素，诸如压力的变化、水头的变化、电位的变化或温度的不同。

土的固相包括不同数量的结晶的黏土和非黏土矿物，非结晶的黏土矿物，有机质和一些可溶性盐。这些矿物通常是由氧、硅、氢、铝等各种元素以不同的结晶形式组成的。土体固体颗粒中的 99%都是由这些元素和钠、钾、镁和碳组成的。虽然在土中非黏土矿物的数量大于黏土矿物，但黏土矿物对土性的影响却是较大的。固体颗粒按大小划分为黏粒、粉粒、砂粒、砾石、粗砾，或块石。

土中液相通常是由水和不同类型、不同数量的溶解电解质组成。土中的有机物，可溶物

和不溶物都来自化学物泄漏，废弃物和污染的地下水。

虽然在一些生物活性大或化学污染的土壤中存在一些有机气体，但是气相，在非饱和土中存在，通常指的是空气。

土的矿物成分决定了土中颗粒的大小、形状和物理化学性质，因此决定了其承载能力和压缩性。

像其他任何工程材料一样，土受力后会变形。这种变形有两种：剪切或滑动变形，不均匀沉降或压缩变形。一般情况下，土体不承受拉力。在某些情况下，由于颗粒间的黏结，土体可能承受较小的拉力，但也不能长时间承受。

**有效应力**

有效应力概念的提出是太沙基在土力学这门学科中做出的最重要的贡献之一。它是描述土骨架所承受的压力大小，反映了土体抵抗剪切应力的能力。有效应力本身不能量测得到，但是可以从其他两个经过量测或经合理准确估计出的参数的差值来计算出。

土体中某一平面上的有效应力是总应力和孔隙水压力的差。

$$\sigma' = \sigma - u$$

总应力 $\sigma$ 等于上覆土的总压力，由土的自重和土表面的其他压力组成。总应力随着深度及覆盖层厚度的增加而增加，

孔隙水压力 $u$ 是水在这个平面上的压力，常用于计算静水压力。在动水作用下有关稳定性的计算(如钢板桩的计算、坝脚下方，或斜坡)中，孔隙水压力 $u$ 必须要根据净流量来估计。同一水平面时，孔隙水压力随着深度的增加而线性增大。

**抗剪强度**

岩土工程中的多数问题，如浅基础和深基础的稳定性问题、边坡稳定问题、挡土墙设计、防渗问题、土壤液化等，都是由土的抗剪强度所决定的。分析抗剪强度这个参数可解决这些工程问题。

土中抗剪强度是抵抗颗粒间相互运动的结果，抗剪强度的形成是由于颗粒间的嵌锁作用，以及沿着接触面上形成物理键，化学键的作用使得颗粒之间有黏结力。

土的应力应变关系，土的抗剪强度，受以下因素影响：

- 土的组成的影响：包括矿物成分，粒径及粒度成分，颗粒形状，孔隙流体类型及含量，颗粒表面及孔隙流体中的离子。
- 初始状态的影响：状态可用下列词语来描述，如疏松、密实、超固结、正常固结、硬、软、收缩、膨胀等。
- 结构的影响：土的结构用以下术语来描述，即未扰动的、扰动的、重塑的、压实的、胶结的、絮状的、蜂窝状的、单粒级的、絮凝的、散凝的、分层的、层状的、各向同性、各向异性。
- 加载条件的影响：加载的有效应力路径，排水，不排水，加载量 ，加载速率，应力历史。

**固结**

固结是土体体积减小的一个过程，当土壤受到压力时会发生，固结后，土中颗粒排列会更紧密，因此土体体积减小。当饱和土固结时，水会排出。固结的程度可用不同的方法来预测。由太沙基提出的经典的方法，可通过固结试验来确定其压缩系数。这可以用来预测固结的程度。

压力去除，土体会反弹，部分压缩的体积会恢复。如果压力再增加，土体将沿着压缩曲

线继续固结。去除压力后的土体被认为是超固结土，如在土体上部曾有冰山覆盖。它曾经受的最大的应力称先期固结压力。土体中目前的压力是曾经受到的最大压力，则这种土称为正常固结土。

**侧向土压力**

侧向土压力理论用来计算垂直于重力的横向压力的大小。这种土压力会在挡土墙上产生。侧向土压力系数 $K$，是用来定义无黏性土的侧向及水平向应力与竖向应力的比值($K=\sigma_h/\sigma_v$)。有三种土压力：静止土压力，主动土压力，被动土压力。静止土压力是土体没有任何位移时产生的侧向土压力；主动土压力是指当墙体在侧向压力作用下背离土体方向移动时，使墙后土体达到极限平衡状态时产生的土压力；被动土压力是指在压力作用下墙体向着土体方向移动使墙后土体达到极限平衡状态时的土压力。有许多理论可以用来估算土压力，有一些是以经验为基础的，有一些是理论分析得到的。

**承载能力**

土体的承载能力是指土体与基础之间的平均接触应力，是土体能够承受的最大的剪应力。允许承载力是指在考虑安全因素的情况下土体的承载能力。有时，在软土地区，加载后土体实际没有发生剪切破坏，在这种情况下，允许承载力就是由建筑物允许的最大变形来控制。

土体破坏的模式有：整体剪切破坏，局部剪切破坏，冲切破坏。

## Section B　边坡上的基础

**引言**

设计在斜坡上或是与斜坡相邻结构的基础时，一定要考虑结构与斜坡的相互作用。

必须要考虑两条准则：

(1) 相邻斜坡对基础承载力和沉降的影响；

(2) 该影响反过来对斜坡稳定性的影响。

第一条准则研究结果表明，由于毗邻斜坡的影响，承载力(水平和竖直方向)能够较大程度降低；第二条很重要，因为在斜坡上或与斜坡毗邻的基础的开挖、基础产生的荷载、或因基础施工产生的地下水短期或长期的变化，都能够影响边坡的稳定性。

在中国香港，典型的基础形式包括扩展基础、沉箱(人工挖掘及机械钻挖)以及桩基础(冲击、钻孔、预制和现浇)。因为重型机械很难在陡坡上进行施工操作，所以扩展基础和人工挖掘沉箱是最常见的基础形式。浅基础(扩展基础)适用于轻负载情况，较深基础(桩基础)则适用于持力层较深或边坡稳定性因基础传来附加荷载而削弱的情况。

**浅基础**

承载能力与沉降

与水平地面上相比，斜坡上浅基础的极限承载能力要低。这种基础极限承载能力的通式在岩土指南第一册(土力工程处，1982)中再次提出，该指南：

(1) 对从坡顶后移基础承载能力的特殊问题做出了评价；

(2) 探讨了其他能够影响承载力的因素。

在斜坡的不同高度施工浅基础时，较高位置的基础要对位置较低的基础产生附加荷载。设计当中一定要考虑此附加荷载。

通常，计算承载力不考虑土壤形成边坡所受到的应力，所以，在负荷基础影响下考虑斜坡整体稳定性是很重要的。然而，土坡抗破坏安全系数符合要求，并不一定意味着沉降也满足要求，而土坡抗破坏安全系数是经过包括基础荷载影响的稳定分析得到的。

边坡稳定性

一般而言，如果坡角大于 Φ’/2 时，应当检验受基础影响的边坡稳定性 (Vesic, 1975)。此时，基础可以看做是等效线荷载，或施加水平和竖向荷载的附加荷载，一并纳入稳定性分析。

基础回填土的力学性能较差，所以，稳定性分析应当考虑在基础的边坡上边缘形成张拉裂缝的可能性。

当浅基础位于岩石边坡处或上方时，稳定性分析应当考虑反向断面引起的潜在不稳定性。在这方面，Hoek & Rray (1981)使用的分析方法很有用。

边坡处或边坡上方浅基础的开挖，以及边坡底部结构支撑的拆除，都可以削弱边坡的稳定性。在分析中这两种后果都应当考虑进去。为了降低边坡短期不稳定性，开挖应当尽可能少，而且还应适当设置支撑。

**深基础**

水平荷载

对于深基础来说，土坡中的水平应力在整个边坡范围内是不同的，而且基础在上坡所受的水平荷载大于下坡处。然而，在边坡抗破坏安全系数满足要求情况下，可以忽略水平荷载大小的差异(Schmidt, 1977)，而且在大多数深基础设计中都不需要考虑。

然而，当地层发生显著运动(即基础上方或下方边坡坍塌，或基础前方边坡遭挖掘)或地层运动很小(即蠕动)而基础刚度非常大时，高侧向荷载能够传递给基础。

由于土的运动引起的对单桩横向荷载的分析有多种方法。Wang & Yen (1974) 和 Ito & Davis (1977)使用了极限平衡方法，建议考虑加密桩之间土的隆起方式。Poulos & Davis (1980)使用了有限差分方法；然而，这些方法取决于桩体周围土层应力-应变关系的正确定义(De Beer, 1977)。

尽可能防止深基础水平荷载的产生。这要通过以下措施来实现：

(1) 基础施工前，加固潜在不稳定边坡；

(2) 基础周围准备环状套管。

环状套管是基础和其周围土壤之间足够宽的区域，该区域内可以充气，也可以填充可压缩材料，而且必须足够宽，从而缓解土的运动及基础偏移。

对于充气区域来说，当必须使用内衬时，内衬必须阻止地下水及地表水进入该区域，而且还要防止土壤进入。应当设计介于内衬与基础之间空气隙顶端塞头，使得不能通过它来传递荷载。

对于内部填充可压缩材料，设计宽度应当考虑材料自身的压缩性，尤其是塑性混凝土浇筑的时候。

在此情况下，可在基础外围安装环形套管，但要确保套管的中心处在基础中心的上坡位置。

边坡稳定

深基础可以通过以下几方面对边坡稳定性产生不利的影响。

(1) 将竖向或水平荷载传递给边坡；

(2) 基础开挖施工过程中支撑的移除；

(3) 基础施工引起地下水暂时或永久性状态的变化。

为阻止竖向荷载传给边坡，深基础的浇筑深度应当低于边坡内任何潜在坍塌面的位置。为阻止水平荷载的传递，应当采用环状套管。此时，套管的安装要偏离基础，使套管中心在基础中心的下坡位处。在不能采取这些措施而且基础传来的荷载有可能传给边坡时，应当评定在这些荷载影响下边坡的稳定性。然而，这种评定不容易，因为稳定性分析常采用的方法(极限平衡法)不适合于评价土压力(塑性方法)。

当沉箱或桩分布很密时，整体透水性能的下降会导致基础上坡位地下水位的上升(Pope & Ho, 1982)。设计时一定要考虑该可能性，而且任何做出的假设都应在基础施工完成后，通过测压计的安装和监测进行核实。

桩基和沉箱可以用来支护边坡，这种情况下结构的设计方法由 Gould (1970)和 Fukuoka (1977)给出。

Section C　桩基础概述

## 引言

桩基础是结构的一部分，用来承受上部结构的荷载并将其传递到地表以下一定深度的地基上。该基础是由桩承台和桩身组成的。当浅土层承载能力不足时，通过设计细长的桩构件，可将荷载传递到具有较高承载力的深土层或岩层上，以达到设计要求。桩所使用材料的主要类型是木材、钢材以及混凝土。用这些材料制作的桩被打入、钻进或用千斤顶压入土层中，并与桩承台相接。桩根据土质的种类、桩身材料及传递荷载性能的不同作出相应的分类。通过下面的文章内容，我们将学习有关桩的功能和种类。

## 桩的功能

同其他种类的基础一样，桩基础的作用是将基础荷载传递到坚硬的土层上，并且能够抵抗竖向、横向及上拔荷载。

如果基础下的土层没有足够的承载能力，结构下部就要设置桩基础。如果地勘结果显示浅层土不稳定，或者预计下沉量较大，这时就要考虑使用桩基础。而且成本预算也显示桩基础可能比其他任何基础改进措施费用都要节省。

对于自重较大的建筑物，当浅层土的承载能力有可能不足够大时，这种情况下建筑物就要建在桩基础上。

## 桩的分类

按照桩的荷载传递方式及性能分为：

- 端承桩(点支撑桩)；
- 摩擦桩(黏聚力桩)；
- 摩擦、黏聚力复合桩。

端承桩将荷载传递到结构基础以下相当深度的坚硬土层上，并且大部分承载能力是因桩尖处土的贯入阻力而产生的。桩具有一般柱的特点，可按照柱来设计。由于土层的侧向约束作用，一般来说桩不会发生屈曲失稳(即使在承载力较低的土层中)，除非其局部区段无土层侧向支撑(即桩的一部分处于悬空状态或在水中时)才会考虑其屈曲失稳破坏的可能。荷载通过摩擦力和黏聚力传递给土壤。但有时桩身周围的土可能粘到桩身表面而产生桩的负摩阻力，对桩的承载力产生相当的影响。负摩阻力是由于土壤中水的排出使土体固结而产生的。桩的埋深要依现场勘查及土壤测试结果而定。

摩擦桩或黏聚力桩的承载力主要是由于土的黏聚力或桩身与土之间的摩擦而产生的。

黏聚力通过桩身摩擦来传递大部分荷载。这种桩的沉桩工序要求群桩中桩与桩之间相互间靠近，从而大大减小群桩范围内及其周围土体的孔隙及压缩性。因此，这类桩有时又被称作挤密桩。沉桩过程中土体受到扰动，其强度会有所降低，故沉桩完毕后一段时间内其承载能力将偏低，通常在沉桩 3～5 个月后才重新恢复。

摩擦桩也能通过其桩身与土的摩擦来传递荷载。这种桩的沉桩过程没有明显地对土进行压缩。这种桩基础通常被称为悬浮桩。

当持力层不硬时，如硬黏土，端承桩则要向下延伸。该桩被沉进较深层的土中来增加摩

擦阻力。除此之外，还可以通过加大端承桩承载面积的办法来进一步提高其承载能力。桩承载面积的扩充可以通过在坚硬土层上方的软土层中灌注混凝土的方法实现。用特殊的挖孔工具在钻孔桩底部形成扩大端也可产生相似的效果。有扩大端头的钻孔桩具有很高的张拉强度，能够用于抗拔桩。

按照材料的种类桩分为：

- 木桩；
- 混凝土桩；
- 钢桩；
- 复合桩。

**木桩**。使用时间最早的而且在木材资源丰富的地区仍将长期使用。木材最适合于长黏聚力桩和堤岸下的桩。木材应当处在材质良好而且不应当遭到昆虫的蛀蚀。木桩桩长小于 14 m，桩尖直径应当大于 150 mm。如果桩长超过 18 m，125 mm 的桩尖直径比较适合。木桩要按照正确的方向打入，不应当打到坚硬土层中，否则容易发生破坏。保持木桩在地下水位线以下，可以保护木材防止腐蚀。为了保护和加强木桩桩尖，桩尖部位应用保护层加以覆盖。压注油浸防腐法是通常使用的保护木桩的方法。

**混凝土桩**。预制混凝土桩或预制装配式混凝土桩，截面通常是方形(如图 10.3(b))、三角形、圆形或八角形。加工尺寸较短，从 3 m 到 13 m，以 1 m 递增。由于是预制，所以很容易将它们接到一起(如图 10.3(a))，从而达到任意深度，这不会降低设计承载能力。桩中设置钢筋有助于抵抗搬运及打桩过程中产生的应力。与普通预制桩相比，由于较少的钢筋需用量而开始使用预应力桩，并且越来越普遍。

**钢桩**。钢桩适合于长尺寸桩的运输和打桩，较小的横截面积和高强度使得它们较容易被打入坚硬土层中，容易被切断或焊接。如果打入 pH 值较低的土层中时，钢桩就会遭遇腐蚀，但腐蚀没有想象中那么严重。通常采用涂刷煤油沥青或阴极保护法来延长钢桩的使用寿命。

通常设计上允许有一定程度的腐蚀，这可以简单通过加大钢桩的横截面积来解决。这样，腐蚀过程可能被延长到 50 年。通常腐蚀速度为每年 0.2～0.5 mm，设计值可以采用每年 1 mm。

**复合桩。**同一桩由不同的材料组成。早期研究表明，木桩的地表水以上部分易遭虫蚀破坏。为避免这种情况发生在地表水以上部分使用混凝土或钢桩，而木桩则被设置到地表水以下位置。



## Grammar：专业英语的翻译技巧(Ⅶ)——重复译法

### Translation Skills of English for Professional Purpose Ⅶ—Repetition

重复法是指在译文中重复原文中重要的或关键的词，以期达到两个目的：一是清楚；二是强调，从而使译文生动有力、清晰流畅。

1. 重复名词

(1) 重复英语中的宾语。

【例 1】 Operators should inspect and oil their *machines* before work.

操作人员在操作前应当检查**机器**，并给**机器**加油。

(2) 重复英语中的先行词。

【例 2】 Water can be decomposed by *energy*, a current of electricity.
水可由**能量**来分解，这里的**能量**是指电流。

2. 重复动词

(1) 重复英语中被代替或共有的动词。

【例 3】 Air pressure *decreases* with increase in altitude and so does the density of the atmosphere.
气压随着高度的增加而**降低**，大气密度也随着高度增加而**降低**。

(2) 重复英语中省略的动词。

【例 4】 Some of the gases in the air are fairly *constant* in amount, while others are not.
空气中的有些气体的含量相当**稳定**，有些就不**稳定**。

3. 重复代词

(1) 英语中代词代替名词的地方。

【例 5】 The conductor has *its* properties, and the insulator has *its* properties.
导体有**导体**的特性，绝缘体有**绝缘体**的特性。

(2) 英语中强调关系代词或关系副词。

【例 6】 You may do the experiment *whenever* you have time.
**什么时候**你有时间，你就在**什么时候**做这个实验。

# Chapter 11

## Highway Design

### Section A Highway Engineering

Highway engineering includes highway planning, location, design, and maintenance. Before the design and construction of a new highway or highway improvement can be undertaken, there must be general planning and consideration of financing. As part of general planning, it is decided what the traffic needs of the area will be for a considerable period, generally 20 years, and what construction will meet those need. To **assess** traffic needs the highway engineer collects and analyzes information about the physical features of existing facilities, the volume, distribution, and character of present traffic, and the changes to be expected in these factors. The highway engineer must determine the most suitable location, layout, and capacity of the new routes and structures. Frequently, a **preliminary** line, or location, and several alternate routes are studied. The detailed design is normally begun only when the preferred location has been chosen.

#### Highway Location

The highway location process involves four phases:

(1) Office study of existing information;

(2) Reconnaissance survey;

(3) Preliminary location survey;

(4) Final location survey.

Traditionally, highway location practice has been field **oriented**, that is, the **bulk** of the location party's time and effort went to measurement and observation "on the ground". The first step towards fixing the road alignment is to take an overall look at the area concerned, select what appear to be possible routes between the terminal points, and then closely examine each of these in turn to decide which will be the most suitable, without actually determining the precise centre-line. This stage of the procedure is termed the **reconnaissance survey** and the form which it takes depends to a great extend on whether or not large-scale **contoured** maps of the area are already available. If large-scale maps are readily obtainable, much of the reconnaissance work can be carried out in advance. By inspecting these maps and drawing **longitudinal sections** along possible **alignments**, a number of alternative routes can be considered, all of which must satisfy the required engineering design standards for horizontal curve **radii** and **gradients**. Reconnaissance of the area was the first step; the **locator**, using available topographic maps and sometimes an airplane, explored the area. His aim was to search out feasible routes and determine such primary controls as

mountain passes or suitable river crossings and to locate major obstacles such as steep slopes or **marshes**.

The basic principle for locating highways is that roadway elements such as **curvature** and grade must blend with each other to produce a system that provides for the easy flow of traffic at the design capacity, while meeting design **criteria** and safety standards. The highway should also cause a minimal disruption to historic and **archeological** sites and to other land-use activities. Environmental impact studies are therefore required in most cases before a highway location is finally agreed upon.

## Alignment Design

The alignment of a road is shown on the **plan view** and is a series of straight lines called **tangents** connected by circular curves. In modern practice it is common to interpose transition or spiral curves between tangents and circular curves. The vertical and horizontal layouts of the highway make up the alignment. The design of the alignment depends primarily on the design speed selected for the highway. For balance in highway design all elements should, as far as economically feasible, be determined to provide safe, continuous at a speed likely under the general conditions for that highway or street.

The least costly alignment is one that generally takes the form of the natural **topography**. Often this is not possible, however, because the designer has to adhere to certain standards that may not exist on the natural topography. It is important that the alignment of a given section has consistent standards to avoid sudden changes in the vertical and horizontal layout of the highway. It is also important that both horizontal and vertical alignments be designed to complement each other, since this will result in a safety and more attractive highway. One factor that should be considered to achieve this is the proper balancing of the grades of tangents with curvatures of horizontal curves and the location of horizontal and vertical curves with respect to each other. For example, a design that achieves horizontal curves with large radii at the expense of **steep or long grades** is a poor design. Similarly, if **sharp horizontal curves** are placed at or near the top of pronounced **crest vertical curves** or at or near the bottom of a pronounced **sag vertical curve**, this will create hazardous sections of the highway. It is important that this coordination of the vertical and horizontal alignments be considered at the early stages of preliminary design.

The vertical alignment of a highway consists of straight sections of the highway known as grades, or tangents, connected by vertical curves. The design of the vertical alignment therefore involves the selection of suitable grades for the tangent sections and the design of the vertical curves. The topography of the area through which the road traverses has a significant impact on the design of the vertical alignment.

The horizontal alignment consists of straight sections of the road, known as tangents, connected by horizontal curves. The curves are usually segments of circles, which have radii that will provide for a smooth flow of traffic along the curve. The design of the horizontal alignment therefore entails the determination of the minimum radius, the determination of the length of the curve, and the computation of the horizontal offsets from the tangents to the curve to facilitate the setting out of a curve.

Detailed design of a highway project also includes preparation of drawings or blueprints to be

used for construction. These plans show, for example, the dimensions of such elements as roadway width, the final profile for the road, the location and type of **drainage** facilities, and the quantities of work involved, including earthwork and surfacing.

## Highway Maintenance

Highway maintenance consists of the repair and upkeep of surfacing and shoulders, bridges and drainage facilities, signs, traffic control devices, **guard rails**, traffic striping on the pavement, retaining walls, and side slopes. Additional operations include ice control and snow removal. Because it is valuable to know why some highway designs give better performance and prove less costly to maintain than others, engineers **supervising** maintenance can offer valuable guidance to design engineers. Consequently, maintenance is an important part of highway engineering.

## Words and Phrases

assess [ə'ses] *vt.* 评价，估计，评定，核定
preliminary [pri'liminəri] *adj.* 初步的，预备的，开端的；*n.*准备工作，初步行动
orient ['ɔ:riənt] *vt.* 定向，定位，使适应，使确定位置
bulk [bʌlk] *n.* 湿胀性，主体
reconnaissance [ri'kɔnisns] *n.* 踏勘，勘察，侦察
contour ['kɔntuə] *n.* 等高线，外形，轮廓
longitudinal [ˌlɔndʒi'tju:dinl] *adj.* 经度的，纵向的
alignment [ə'lainmənt] *n.* 线形，定线，排列成行
radii ['reidiai] *n.* (复数)半径
gradient ['greidiənt] *n.* 坡度，梯度，斜率
locator [ləu'keitə] *n.* 定位器，探测器
marsh [mɑ:ʃ] *n.* 沼泽，湿地
curvature ['kə:vətʃə] *n.* 曲率，曲度，弯曲
criterion [krai'tiəriən] (*pl* -ria) *n.* 指标，准则
archaeological [ˌa:ki'ɔlədʒikəl] *adj.* 考古学的
tangent ['tændʒənt] *n.* 切线，正切，直线
topography [tə'pɔgrəfi] *n.* 地形，地貌，地势
drainage ['dreinidʒ] *n.* 排水，排水系统，下水道
supervise ['sju:pəvaiz] *vt.&vi.* 监控，管理
highway location 定线
reconnaissance survey 踏勘测量
longitudinal section 纵断面，纵断面图
plan view 平面图
steep(long)grade 陡(长)坡
sharp horizontal curve 急弯平曲线，小半径平曲线
crest(sag)vertical curve 凹(凸)形竖曲线
guard rail 护栏，护轨

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. A design that achieves horizontal curves with large radii at the expense of steep or long grades is a ________ design.

2. The highway location process involves four phases: office study of existing information; ________ survey; ________ location survey; Final location survey.

3. To assess traffic needs the highway engineer collects and analyzes information about the physical features of ________ facilities, the volume, ________, and ________ of present traffic, and the ________ to be expected in these factors.

4. The design of the alignment depends primarily on the ________ selected for the highway.

Ⅱ. Translate the following passages from English into Chinese.

Preliminary analysis of the data obtained will indicate whether any of the specific sites should be excluded from further consideration because of one or more of the above characteristics. For example, if it is found that a site of historic and archeological importance is located within an area being considered for possible route location, it may be immediately decided that any route that traverses that site should be excluded from further consideration. At the completion of this phase of the study, the engineer will be able to select general areas through which the highway can traverse.

The primary object of reconnaissance survey is to identify several feasible routes with a strip, then drawing on photographic maps. The preliminary reconnaissance will have established primary and secondary controls for one or more feasible routes and will have fixed each location within a band of limited width, possibly within a few hundred feet. The second stage is to set the position of alternate routes by establishing all control points and fitting tentative vertical and horizontal alignment to them, and by roughly estimating their relative costs. Photogrammetry and computers permit more alternatives to be examined than could be done in the field.



# Section B Subgrade and Pravement

The purpose of a **pavement** is providing a smooth surface over which vehicles may pass under all climatic conditions. In turn, the performance of the pavement is affected by the characteristics of the **subgrade**.

## Subgrade

Highway subgrade (or **basement soil**) may be defined as the supporting structure on which pavement and its special under-courses rest. In cut sections, the subgrade is the original soil lying below the special layers designated as base and subbase material. In fill section, the subgrade is constructed over the native ground and consists of imported material from nearby roadway cuts or from **borrow pits**.

The cross-sectional shape of the subgrade depends on the type of surfacing, if any, which is to

be used. On earth roads, the subgrade, which is also the surface course, is shaped to the standard road cross section. If the road is to be surfaced, the subgrade is graded to the same slope as the finished surface. If the trench method is used, the earth escalated to form a trench is pushed to the sides of the road to form retaining shoulders.

The weight and number of vehicles began increasing, which imposed larger and more numerous wheel loads on the roadway surface. In many instances, **subsidence** or even total failure of the roadway resulted. Study of such failures indicated that the fault lay in the subgrade and not in the pavement. This in turn led to the investigation of the properties of subgrade soils and of their performance under service conditions. Desirable properties which the subgrade should possess include strength, drainage, ease of compaction, permanency of compaction, and permanency of strength.

The subgrade is usually the natural material located along the horizontal alignment of the pavement and serves as the foundation of the pavement structure. The subgrade may also consist of a layer of selected borrow materials, well compacted to **prescribed** specifications. It may be necessary to treat the subgrade material to achieve certain strength properties required for the type of pavement being constructed. Since subgrades vary considerably, it is necessary to make a thorough study of the soils in place and, from this, to determine the design of the pavement. Soil is a highly variable material, the interrelationship of soil texture, density, **moisture** content, and strength are complex, and, in particular, behavior under repeated loads is difficult to evaluate. Because of the complexity of the problem, it is not possible to **set down** rules which will be suitable for all cases. Nevertheless, it is possible to formulate techniques and procedures which will give satisfactory results if the principles involved in design of the subgrade are readily understood by the design engineer.

## Pavement

A highway pavement is a structure consisting of **superimposed** layers of selected and processed materials placed on a subgrade, whose primary function is to support the applied traffic loads and distribute imposed wheel loads over a large area of the natural soil. If vehicles were to travel on the natural soil itself, shear failures would occur in the wheel path in most soils, and **ruts** would form. The shear strength of the soil is usually not high enough to support the load. In addition to its load distribution function, the surface course of a highway or airport pavement structure must provide a level, safe traveling surface. The ultimate aim is to ensure that the transmitted stresses are sufficiently reduced that they will not exceed the **supporting capacity** of the subgrade.

Highway pavements are divided into two main categories: **flexible pavements** and **rigid pavements**, depending on how they distribute surface loads. The **wearing surface** of flexible pavements is usually constructed of **bituminous** material such that they remain in contact with the underlying material even when minor irregularities occur. The wearing surface of a rigid pavement, on the other hand, is usually constructed of **Portland cement** concrete such that it acts like a beam over any irregularities in the underlying supporting material.

The essential difference between the two types of pavement, flexible and rigid, is the manner in which they distribute the load over the subgrade. The rigid pavement, because of its **rigidity** and high modulus of elasticity, tends to distribute the load over a relatively wide area of soil; thus, a major portion of the structural capacity is supplied by the **slab** itself. The major factor considered in

the design of rigid pavements is the structural strength of the concrete. For this reason, minor variations in subgrade strength have little influence upon the structural capacity of the pavement. Rigid highway pavement is divided into three general types: plain concrete pavement, **simply reinforced concrete pavement**, and **continuously reinforced concrete pavements**. Rigid highway pavements usually are constructed to carry heavy traffic loads, although they have been used for residential and local roads. Properly designed and constructed rigid pavements have long service lives and usually are less expensive to maintain than the flexible pavements.

The **load-carrying capacity** of flexible pavements is brought about by the load-distributing characteristics of the **layered system**. The components of a flexible pavement include the subgrade or **prepared roadbed**, the subbase, base course, and the **surface course**. The performance of the pavement depends on the satisfactory performance of each component, which requires proper evaluation of the properties of each component separately. Ideally, the pavement is built to a depth where stresses on any given layer will not cause undue rutting, shoving, and other differential movements resulting in an uneven wearing surface.

Flexible pavements are further divided into three subgroups: high type, intermediate type, and low type. **High-type pavements** have wearing surfaces that adequately support the expected traffic load without visible distress due to **fatigue** and are not **susceptible** to weather conditions. Intermediate-type pavements have wearing surfaces that range from **surface treated** to those with qualities just below that of high-type pavements. Low-type pavements are used mainly for low-cost roads and have wearing surfaces that range from untreated to **loose natural materials** to surface-treated earth.

## Words and Phrases

pavement ['peivmənt] *n.* 铺过的路面，硬路面
subgrade ['sʌbgreid] *n.* 地基，路基
subsidence ['sʌbsidəns] *n.* 沉降，陷没，下沉
prescribed [pri'skraibd] *adj.* 规定的，法定的
moisture ['mɔistʃə] *n.* 水分，水汽，湿度，潮度
superimpose [ˌsju:pərim'pəuz] *v.* 添(附)加，重叠
rut [rʌt] *n.* 车辙，凹槽；*vt.* 形成车辙
bituminous [bi'tju:minəs] *adj.* (含)沥青的
rigidity [ri'dʒiditi] *n.* 刚度，坚硬，刚性，硬度
slab [slæb] *n.* 板，板状物，厚板
fatigue [fə'ti:g] *n.* 疲劳，劳累
susceptible [se'septəbl] *adj.* 能经受的，易受影响的，过敏的
basements oil 土路基，基土
borrow pit 取土坑，借土坑
set down 规定，制定
supporting capacity 承载能力
flexible(rigid)pavement 柔性(刚性)路面
wearing surface (路面)磨耗层

Portland cement 波特兰水泥，普通硅酸盐水泥
simply (continuously) reinforced concrete pavement 普通(连续)加筋混凝土路面
load-carrying capacity 承载能力，载重量
layered system 层状体系
prepared roadbed 填筑好的路基
surface course 面层
high-type pavement 高级路面
surface treated 表面处治
loose natural material 天然松散材料

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The subgrade may also consist of a layer of selected ________ materials, well compacted to prescribed specifications.
2. A highway pavement is a structure consisting of ________ layers of selected and processed materials placed on a ________, whose primary function is to support the applied traffic loads and ________ imposed wheel loads over a large area of the natural soil.
3. Highway pavements are divided into two main categories: ________ pavements and ________ pavements, depending on how they distribute surface loads.
4. Soil is a highly ________ material, the interrelationship of soil texture, density, ________ content, and strength are complex, and, in particular, behavior under ________ loads is difficult to evaluate.

Ⅱ. Translate the following passages from English into Chinese.

The structure of the flexible pavement is composed of a "wearing surface", base, subbase (not always used), and subgrade. The base is a layer (or layers) of very high stability and density. Its principal purpose is to distribute or "spread" the stresses created by wheel loads acting on the wearing surface so that the stresses transmitted to the subgrade will not be sufficiently great to result in excessive deformation or displacement of that foundation layer. The base must also be of such character that it is not damaged by capillary water and/or frost action. Locally available materials are extensively used for base construction, and materials preferred for this type of construction vary widely in different sections of the country. For example, the base may be composed of gravel or crushed rock or it may be a granular material treated with asphalt, cement, or lime-fly ash stabilizing agents. The distinguishing feature of a flexible pavement lies in its structural mechanics and the fact that the pressure is transmitted to the subgrade through the lateral distribution of the applied load with depth, rather than by beam and slab action as with a concrete slab. Thus a flexible pavement can be most easily defined by contrasting it with a rigid Portland cement concrete pavement.

# Section C Highway Cross Section

The principal elements of a highway cross section consist of the **travel lanes**, **shoulders**, and **medians** (for some **multilane highways**). **Marginal** elements include median and roadside barriers, **curbs**, **gutters**, **guard rails**, **sidewalks**, and **side slope**. Fig. 11.1 (a) shows a typical cross section for a two-lane highway, and Fig. 11.1 (b) shows that for a multilane highway. Dimensions for each element are based on careful analysis of the volume, character, and speed of traffic and of the characteristics of motor vehicles and their operators.

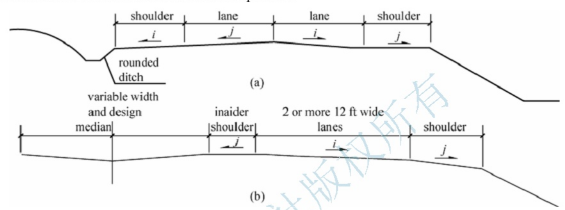



Fig.11.1 Typical Cross Section for Highways

## Lane Widths

In meeting oncoming vehicles or passing slower ones, the position selected by a driver depends primarily on the paved or surfaced width of the highway. Originally this surfaced width was only 15 ft, which was ample for horse-drawn vehicles. With the increase in motor-vehicle traffic the width increased first to 16 ft, then to 18 ft. Later two 10 ft lanes became a standard width for first-class, paved highways and now, with increased vehicle speeds, 24 ft widths of pavement are regarded as necessary for freeways and rural highways carrying high traffic volumes.

Travel lane widths usually vary from 10 ft to 12 ft. most **arterials** have 12 ft travel lanes since the extra cost for constructing 12 ft lanes over 10 ft lanes is usually offset by the lower maintenance cost for shoulders and pavement surface, resulting in the reduction of wheel concentrations at the pavement edges.

## Shoulders

The shoulder is that portion of the roadway between the outer edge of the traffic lane and the inside edge of the **ditch**, gutter, curb, or slope. Divided highways also may have an inside shoulder between the inside lane and the median. The shoulder is **contiguous** with the traveled lane and provides an area along the highway for vehicles to stop, particularly during an emergency. Shoulders are also used to laterally support the pavement structure. If design omits shoulders, or if they are narrow, roadway capacity decreases and accident opportunity may increase.

The shoulder width is known as either graded or usable, depending on the section of the shoulder being considered. The **graded shoulder** width is the whole width of the shoulder measured from the edge of the traveled pavement to the intersection of the shoulder slope and the plane of the side slope. The **usable shoulder** width is that part of the graded shoulder that can be used to accommodate parked vehicles. When a vehicle stops on the shoulder, it is desirable for it to be at least 1 ft and preferably 2 ft from the edge of the pavement. Based on this, AASHTO recommend that usable shoulder widths of at least 10 ft and preferably 12 ft be used on highways having a large number of trucks and on highways with high traffic volumes and high speeds. Today, the full shoulder width often is paved or treated with bituminous material. In the East, South, and Midwest, where rainfall is sufficient and frequent enough to support grass, **turfed** shoulders so constructed as to provide firm support for vehicles are widely used.

It is essential that all shoulders be **flushed** with the edge of the traveled lane and be sloped to facilitate the drainage of surface water on the traveled lanes. Recommended slops are 2 percent to 6 percent for **bituminous and concrete-surfaced shoulders**, and 4 percent to 6 percent for **gravel or crushed-rock shoulders**.

## Medians for Multilane Highways

A median is the section of a divided highway, which separates the lanes in opposing directions. Positive separation between opposing streams of traffic has proved to be an effective means for reducing headlight glare, conflicts, and accidents on multilane highways. Today medians in some form are an absolute requirement for all freeways.

The width of a median is the distance between the edges of the inside lanes, including the median shoulders. Median widths vary from a minimum of 2 ft to 80 ft or more. Median widths should be as wide as possible but should be balanced with the other element of the cross section and the cost involved. In general, the wider the median, the more effective it is in providing safe operating conditions. The functions of a median include: (1) providing a recovery area for out-of-control vehicles; (2) separating opposing traffic; (3) providing stopping areas during emergencies; (4) providing storage areas for left-turning and U-turning vehicles; (5) providing **refuge** for pedestrians; (6) reducing the effect of headlight glare; (7) providing temporary lanes and cross-over during maintenance operation.

Medians can either be **raised medians**, **flush medians**, or **depressed medians**. Raised medians are frequently used in urban arterial streets because they facilitate the control of left-turn traffic at intersections by using part of the median width for **left-turn-only lanes**. Flush medians are commonly used on urban arterials. They can also be used on freeways, but with a median barrier. Depressed medians are generally used on freeways and are more effective in draining surface water. A side slope of 6∶1 is suggested for depressed medians, although a slope of 4∶1 may be adequate.

## Side Slopes

Earth fills of usual height stand safely with side slopes of 1.5 to 1. The side slopes of cuts through ordinary undisturbed earth remain in place with slopes of 1. Rock cuts as steep as 0.5 to 1 and sometimes 0.25 to 1 are stable. In recent, side slopes generally have been **flattened** to provide

for safer operation and decreased maintenance.

**Steep** side slopes on fills create a serious accident hazard. If one wheel of a vehicle goes over the edge, the driver losses control. Overturn may result. With flat slopes the car can often be directed back into the road or continue safely down the slope. AASHTO standards now demand flat slopes on the roadway side of gutter ditches and at the top of the fill slopes. Standards for the Interstate System recommend that side slopes be no steeper than 4 to 1 and never steeper than 2 to 1 except in solid rock or other special soils.

## Cross Slope

Cross slope is introduced in all tangent sections of roadway. Except where super-elevation of carves directs all water toward the inside, slopes usually fall in both directions from the center line of two-lane highways. For high-type pavements, this cross slope is often 1/8 in. per foot to 1/4 in. per foot. For cheaper pavements constructed to less-exacting standards the cross slope is greater. On paved shoulder cross slopes are usually greater, in the range of 3/8 in. to 1/2 in. per foot. For gravel and turf even greater slopes are needed for satisfactory drainage.

## Words and Phrases

lane [lein] *n.* 车道，小路
shoulder [ˈʃəuldə] *n.* 路肩，肩部
median [ˈmiːdjən] *n.* 中间带；*adj.*中央的，当中的
marginal [ˈmɑːdʒinəl] *adj.* 边缘的，边际的，界限的
curb [kəːb] *n.* 路缘石，道牙，侧石；*vt.*设路缘石
gutter [ˈgʌtə] *n.* 排水沟，阴沟，雨水沟
sidewalk [ˈsaidwɔːk] *n.* 人行道，步道
arterial [ɑːˈtiəriəl] *adj.* 干线的，主干的，动脉的
ditch [ditʃ] *n.* 沟，沟渠，壕沟
contiguous [kɔnˈtigjuəs] *adj.* 接触着的，邻近的，相邻的
turf [təːf] *n.* 草皮，草皮块
flush [flʌʃ] *vt.* 使齐平，弄平，嵌平
refuge [ˈrefjuːdʒ] *n.* 安全岛，避车台，避难
flatten [ˈflætn] *vi.* 变平，与……齐平
steep [stiːp] *adj.* 陡的，急剧升降的
travel lane 行车道，车行道
multilane highway 多车道公路
guard rail 护栏
side slope 边坡
graded shoulder 整形路肩
usable shoulder 有效路肩
bituminous and concrete-surface shoulder 沥青和混凝土面层的路肩
gravel or crush-rock shoulder 砾石或碎石路肩
raised median 上凸式中间带

flush median 齐平式中间带
depressed median 下凹式中间带
left-turn-only lane 专用左转车道
cross slope 横坡，横向坡度

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. With ________ slopes the car can often be directed back into the road or continue safely down the slope.

2. The principal elements of a highway cross section consist of the ________, shoulders, and ________ (for some multilane highways).

3. The shoulder is contiguous with the ________ lane and provides an area along the highway for vehicles to stop, particularly during an ________.

4. Medians can either be ________ medians, ________ medians, or depressed medians. ________ medians are commonly used on urban arterials.

5. The shoulder is that portion of the roadway between the ________ edge of the traffic lane and the ________ edge of the ditch, gutter, curb, or slope.

Ⅱ. Translate the following passages from English into Chinese.

The material composing any slope has a natural tendency to slide under the influence of gravitational and other forces (such as those due to tectonic stresses, seismic activity etc.) which is resisted by the shearing resistance of the referral. Instability occurs when the shearing resistance is not enough to counterbalance the forces tending to cause movement along any surface within a slope. Natural slopes, which have been stable for many years may suddenly fail due to one or more causes, such as external disturbance in the form of seismic activity (earth tremors or earthquake); progressive decrease in shear strength of slope materials; progressive in the stress field within a slope; weathering and so on.

The very first roads were really tracks beaten in the ground by wild animals in prehistoric times. People followed these winding trails because they provided an easy and quick way to get through thick forests. In time, people began to improve the paths by filling holes with earth and laying logs across soft, boggy spots. These attempts were crude, but they were the beginning of road construction. Later in history, when well-traveled routes were made sturdier with rocks and stones, the path was raised above the surrounding land; it became a ‘high way’.

# 参 考 译 文

## 第 11 章　公 路 设 计

Section A　公路工程

公路工程包括规划、定线、设计和维护。在一条新建公路或者改建公路设计施工前，必须进行整体规划和资金考虑。作为整体规划中的一部分，首先要确定相当一段时间内当地的

交通需求，一般为 20 年，还有就是修建什么样的工程将会满足交通需求的需要。为了准确估计交通需求，工程师要收集分析很多信息，其中包括现有设施的特点，交通量、交通分布、当前的交通特点，以及预估的这些信息可能发生的变化。公路工程师必须由此确定最合适的位置、布局、新路线通行能力和结构的承载能力。通常情况下就是进行初步的选线、定线，以及多条路线的必选，而具体的设计只能是在首选线路明确后再开始进行。

**公路定线**

公路定线的过程一般包括四个阶段：

(1) 现有资料室内研究；

(2) 踏勘测量；

(3) 初步定线；

(4) 最终定线。

传统的公路定线的做法都是在野外进行的，也就是说，定线工作要花大量的时间和精力在现场进行测量和观察。第一步，选定路线是要对相关地区进行全面审视的，在起终点间选择可能的路线，之后仔细考察每一个方案以决定最合适的路线，此时不需要确定准确的道路中心线位置。这一阶段又被称为踏勘测量，踏勘采取的形式很大程度上依赖于该地区是否具有已经应用的大比例地形图。如果大比例地形图很容易获得，那么踏勘工作的大部分就得以提前实施。通过审查这些地图和沿着可能的线向绘制纵断面可以考虑许多比较路线，所有这些路线必须符合工程设计标准要求的平曲线半径和坡度。现场踏勘是定线的第一步，之后就可以利用现有的地形图有时甚至利用飞机，用定位器对现场进行勘查。它的目标就是寻找可行的路线并确定基本的控制点，例如沿线的山脉、跨越的河流，以及找出主要的障碍，包括陡坡或沼泽。

定线的基本原则是车行道要素如曲度和坡度必须互相组合，在满足设计规范和安全标准的要求的同时，提供满足设计通行能力并且平稳的交通流体系。这条公路还应该对历史和考古遗迹以及其他土地利用活动造成的干扰最小化。在最终确定公路线路之前，大多数情况下还需要进行环境影响研究。

**线形设计**

道路的线形以平面图形式给出，是由圆曲线连接的一系列称为切线的直线段所组成。现在的做法通常是在切线和圆曲线之间插入缓和曲线和螺旋曲线。公路的垂直和水平布置组成了线形。线形的设计主要取决于公路限定的设计车速。为了保证道路设计的均衡，所有设计要素的确定，只要是经济上可行的，都应在公路或城市道路的一般条件下能够提供车辆安全、连续的行驶条件。

最经济的线形设计一般是一条顺应自然地形的路线。然而，这通常是不可能的，因为设计师必须遵循一些特定的技术标准，而这些标准也许并不能适应地形。重要的是给定截面的线形要保持标准统一，避免公路的纵向和横向布局上出现突变。还有同等重要的就是纵向线形和水平线形设计要彼此协调，这样才能营造安全和更有吸引力的行车环境。为了达到这一点，一个应该考虑的因素是适当地保持直线坡度和平曲线曲率的平衡，处理好平曲线和竖曲线之间的相互位置。例如，如果设计是一个大半径平曲线并伴随陡长坡的话，那么这个设计是失败的。同样，急弯平曲线如果设置于凸形竖曲线顶部或附近以及凹形竖曲线底部或附近的话，那样会产生公路的危险断面。重要的是这种平竖曲线的协调要在初步设计阶段早期予以考虑。

公路纵断面线形的构成包括由竖曲线连接的道路直线段，也就是熟知的坡度或者切线。

纵断面线形设计因此也涉及了适应切线段的合适坡度和竖曲线设计。道路所通过地区的地形图对于纵断面线形的设计具有非常重要的影响。

平面线形包括由平曲线连接的道路直线段，也就是熟知的切线。曲线通常为圆曲线，该曲线半径要求能够提供一条畅通的道路。因此，平面线形的设计包括确定最小半径和曲线的长度，以及计算从切线到曲线的横向偏移，以有助于确定曲线的线形。

公路项目的详细设计工作还包括了编制用于施工的图纸或设计图。这些图纸显示了比如道路宽度等尺寸大小、道路最终的轮廓图、排水设施的位置和类型，工程涉及的工程量，包括土方工程和路面工程。

**公路维护**

公路维护包括路面、路肩、桥梁、排水设施、信号、交通控制设施、护栏、交通标线、挡土墙和边坡的维修和保养。附加工作还包括除冰和除雪。因为了解一些公路设计运行良好并且维护造价低的原因是很有必要的，所以维护监理工程师可以为设计工程师提供很有价值的指导。总之，维护是公路工程中非常重要的一部分。

## Section B　路基路面

路面的主要作用就是在任何气候条件下提供车辆通行所需的平顺的表面。相应的路面性能会受到路基特性的影响。

**路基**

公路路基(或土路基)被定义为路面和下面层的支撑结构。在挖方断面上，路基是位于面层下部作为基础材料的原状土壤。在填方断面上，路基修建在天然土层上和由附近挖方或外调土方所构成的土层上。

路基的横断面形状取决于使用中的路面类型，如果有路面的话。在土路上，路基也是上面层，并且构成了标准的道路横断面。如果道路需要罩面的话，路基坡度要和已经完成的面层保持一致。如果采用路槽法，那么要将做路槽所挖出的土堆到道路两侧以便形成起支挡作用的路肩。

由于机动车重量和数量的不断增加，道路路面也将承担更大和更多数量的轮载。在很多情况下，这会导致道路下沉甚至是完全失效。研究表明，这种破坏是由于基层而不是面层。这也引起了对路基土壤及其在工作条件下的性能进行研究。路基应该具有的性质包括强度、排水、便于压实、压实耐久性和强度耐久性。

路基一般都是位于道路平面线形附近的天然材料，其作用是作为路面结构的基础。其组成也可以是一层经过选择并且充分压实达到规范规定的外调材料。对于路基材料必须进行必要的处理使其能够达到一定的强度特性来满足路面施工的要求。因为路基土的差别很大，所以对现场土壤需要进行深入的研究以确定路面的设计。土壤是一种高度可变的材料，土质间的相互影响、密度、含水量以及强度都很复杂，尤其是在反复荷载作用下的性能很难评估。因为问题的复杂性，所以很难制定一个统一的规则来适应所有情况。然而，可能做到的就是制定相关的技术和程序来给出满意的解决方案，这样设计师就会很容易理解路基设计原理了。

**路面**

路面就是位于路基之上的由选择和处理过的材料叠合而成的结构，它的主要功能是支撑交通荷载并且将车轮荷载分布到下部大面积的天然土层之中。如果车轮直接行驶于天然土层上，那么在车轮痕迹的位置有可能发生剪切失效，随后形成车辙。通常土壤的抗剪切强度是不高的，不足以抵抗荷载。除非所承担的荷载进行了扩散，道路或机场的路面结构才能提供

安全的行驶表面。最终目的是保证所传递的应力可以充分的降低，使之不超过路基的承载能力。

根据路面荷载的分布情况，公路路面分为两大类：柔性路面和刚性路面。柔性路面的磨耗层通常由沥青材料铺筑而成，这样即使出现小的缺陷，它也会和下卧层保持紧密联系。另一方面，刚性路面的磨耗层通常用水泥混凝土铺筑，其作用与梁一样，支撑在不平整的下部材料上工作。

两种类型路面，柔性路面和刚性路面的本质区别是它们将荷载分配到路基的方式不同。由于刚性路面刚度大和弹性模量高，往往会把荷载分布到比较大面积的土壤中，这样结构承载力的主要承担部分就是板本身，在进行刚性路面的设计时，需要考虑的主要因素是混凝土的强度。正因为这个原因，即使路基强度出现微小的变化也不会影响路面承载能力。刚性公路路面划分为三种类型：素混凝土路面，普通加筋混凝土路面和连续加筋混凝土路面。尽管刚性路面道路已经应用于民用和地方道路，但是通常它可以承担重交通荷载。如果设计得当并且保证施工质量，刚性路面的使用寿命会很长，而且其维护费用比柔性路面要低。

柔性路面的承载能力是由层状系统的荷载分布特性提供的。柔性路面的组成部分包括天然路基或填筑好的路基、底基层、基层和面层。路面的性能取决于各组成部分的性质，这就要求对每个部分分别进行准确的评价。最理想的情况是所修建的路面深度范围内，任何一个给定的层间都不会引起车辙、拥包和导致磨耗层不平整的变相差。

柔性路面进一步可分为三个类型：高级、中级和低级。高级路面的磨耗层能有效地承担预期的车辆荷载，而不会出现明显的疲劳破坏，并且不易受气候的影响。中级路面的磨耗层无论是表面处理或是路面本身的质量都仅低于高级路面。 低级路面主要用于低成本道路，它的磨耗层是表面未经处理的天然松散材料。

Section C　公路横断面

公路横截面的主要组成部分包括行车道、路肩、中间带(对一些多车道公路而言)。边缘部分包括：中间或路侧栏杆、路缘石、边沟、护栏、人行道以及边坡。图 11.1 (a)所示是一个典型的双车道公路的横断面，图 11.1 (b)所示为多车道公路的横断面图。其中每一个部分的尺寸都是在认真分析的基础上得出的，包括对交通量、交通特性、车速、机动车特性、驾驶员特性等。

**行车道宽度**

在会车或者超车时，司机对于位置的选择主要依赖于所铺筑道路表面的宽度。起初这个表面的宽度仅为 15 ft(1 ft=0.3048 m)，这对于马车是足够了。随着汽车交通的增加，宽度首先增加到 16 ft，之后为 18 ft，随后 20 ft 成为一级铺筑公路的标准宽度。现在，随着机动车车速的提高，对于高速公路和交通量较大的乡村道路，其路面宽度有必要达到 24 ft。

一条行车道的宽度范围一般为 10～12 ft。大多数干线车行道宽 12 ft，因为修建一条 12 ft 车行道比 10 ft 车行道超出的额外费用通常被路肩和路面较少的养护费抵消了，而且还可以减轻路面边缘的轮载集中现象。

**路肩**

路肩是公路的一部分，它位于外缘车道和边沟、路缘石、边坡内侧之间。分离式公路也可能存在内侧路肩，它位于内侧车道与中间带之间。路肩与行车道相连，为机动车在路边的临时停靠提供了场地，尤其遇到紧急情况时。路肩也用于横向支撑路面结构。如果设计时忽略了路肩或是宽度不够，那么道路通行能力就会降低并且交通事故发生概率也会增大。

路肩的宽度包括整幅宽度和有效宽度，这取决于路肩的断面形式。其中整幅路肩宽度为路肩的全部宽度，从行车道边缘到路肩斜坡与边坡水平面交汇处量取。有效路肩宽度是整幅路肩的一部分，它可以用于停泊来往车辆。当车辆停靠在路肩上时，需要至少距离路面边缘有 1 ft 的富裕，最好是 2 ft。在此基础上，对于有大量大车通过的公路和交通量大、车速高的公路，AASHTO 推荐有效路肩的宽度至少为 10 ft，最好是 12 ft。如今，整幅路肩都用沥青材料铺筑或处理。在东部、南部和中西部雨量充足能够维持草类生长的地方，修建草皮路肩用以停靠车辆得到广泛应用。

路肩必须与车道边缘齐平这一点很重要，并且形成一定的坡度以便路表面雨水的排泄。推荐沥青和混凝土面层的路肩坡度为 2%～6%，砾石或碎石路肩坡度为 4%～6%。

**多车道公路的中间带**

中间带是分隔式公路的组成部分，用以分隔对向车流。在多车道公路上，对于减少前灯眩光、冲突和事故，分离对向车流被证明是一种非常有效的措施。当下对于所有高速公路，不同形式的中间带是绝对需要的。

中间带的宽度就是内侧车道内边缘间的距离，其中包括中间带路肩。中间带宽度范围为 2～80 ft 甚至更大。中间带应该尽可能宽一些，但还要兼顾横断面其他部分和整体造价。总的说来，中间带越宽，它所提供的安全驾驶条件就越有效。中间带的作用包括：(1) 为失去控制的车辆提供缓冲区；(2) 分隔对向车流；(3) 紧急事件发生时提供车辆的停靠场所；(4) 为左转和掉头车辆提供储备区；(5) 为行人提供安全岛；(6) 降低车头灯眩光的影响；(7) 在维修作业时提供临时车道和横穿区域。

中间带可以是上凸式中间带，齐平式中间带或者下凹式中间带。上凸式中间带经常用于城市主干道，因为它有助于控制交叉口的左转车流，通过利用部分中间带宽度作为专用左转车道。齐平式中间带通常用于城市干道，也可以用于具有中间护栏的高速公路。下凹式中间带经常用于高速公路，并且能够更有效地排除地表水。对于下凹式中间带建议边坡采取 6∶1 的坡度，尽管 4∶1 的坡度可能就足够了。

**边坡**

一般高度的填方边坡安全坡度为 1～1.5。当边坡穿越原地未受干扰土体时，合适的坡度为 1。对于石砌边坡，其稳定坡度为 0.5～1，有时可以为 0.25～1。近来，为了安全作业和减少养护，边坡一般都被设计得平缓了。

过陡的边坡会造成很严重的事故。如果车辆的一个车轮驶出了车道边缘，驾驶员将失去对车辆的控制，进而引起翻车事故。如果是平缓的坡度，失控车辆往往可以直接返回道路上或者沿着坡度继续安全行驶。现今，AASHTO 标准要求道路边沟一侧和填方顶部的坡度要尽量平缓。而洲际标准建议边坡坡度不要超过 1∶4，禁止超过 1∶2，其中坚实的岩体和特殊土质除外。

**横坡**

在所有道路横断面中都含有横坡。除非横向设计为外侧超高使所有积水流向内侧，横坡都是由双向车道的中心线指向两侧的。对于高级路面，公路横坡通常为 1/8～1/4/(in/ft)。而对于低造价和低标准的路面建设横坡会更大。对于铺筑路肩横坡往往会加大，范围从 3/8～1/2/(in/ft)。为了满足排水要求对于碎石和草皮路面其横坡会更大。

# Grammar：专业英语的翻译技巧(Ⅷ)——长句翻译

## Translation Skills of English for Professional Purpose Ⅷ—Long Sentences

按照英语的语法结构和修辞手段，利用介词短语、分词短语、不定式短语和各种并列结构，可以构成很长的简单句；利用适当的连词又可将许多句子组合成更长的复杂句，如并列复合句和主从复合句等，这样，往往是从句之中有分句，分句之中又有从句。相比之下，汉语的特点是使用较多的动词和较少的连词，靠词序和逻辑关系来组织句子，句子中的各部分(分句或独立短语)一般不太长。因此，翻译时首先要弄清楚原文的句法结构，找出整个句子的中心内容及其各个部分意思，然后分析相互间逻辑关系，再根据汉语的行文习惯，重新加以组织，力求在“明确”的基础上，做到“通顺”和“简练”。

英语长句汉译通常采用顺译、倒译、拆译并重新组织等三种方法，而且往往需要同时并用几种方法。

1. 顺译法

对专业英语而言，只要不大违反汉译的行文习惯和表达方式，一般应尽量采用顺译。顺译有两个长处：一是可以基本保留英语语序，避免漏译，力求在内容和形式两方面贴近原文；二是可以顺应长短句相替、单复句相间的汉语句法修辞原则。

(1) 在主谓连接处切断(用“｜”表示)。

【例 1】 The rapid growth from 1945 onwards in the prestressing of concrete｜shows that there was a real need for this high-quality structural material.

1945 年以来预应力混凝土的迅速发展，反映了这种高质量结构材料的实际应用。

(2) 在并列或转折连接处切断。

【例 2】The design of the horizontal alignment entails the determination of the minimum radius, the determination of the length of the curve, ｜and the computation of the horizontal from the tangents to the curve to facilitate the setting out of the curve.

平面曲线设计要求确定最小半径，确定曲线长度，并计算从切线到曲线的平距，以便进行曲线放样。

(3) 在从句前切断。

【例 3】 In the design of flexible pavement, the pavement structure is usually considered as a multilayered elastic, ｜with the material in each layer characterized by certain physical properties ｜that may include the modulus of elasticity, the resilient modulus, and the Poisson ratio.

在柔性路面结构中，通常把路面结构看成多层弹性体系，每层材料的特点在于某些物理性质，其中包括弹性模量、回弹模量和泊松比。

2. 倒译法

在英译汉时，常常需根据汉语的习惯表达方式将英语长句进行全部倒置或局部倒置。当然，翻译时只要能做到顺译，就不一定非倒置不可，在大多数情况下，倒置也只是一种变通手段，并不是唯一可行的办法。

(1) 将英语原句全部倒置。

【例 4】 About one third of all accidents happen when it is dark, although obviously there is more traffic during daytime.

虽然在白天交通运输显然繁忙得多，但大约 1/3 的事故发生在晚上。

(2) 将英语原句部分倒置(将句首或首句置于全句之尾)。

【例 5】 It is most important that the specification should describe every construction item which enters into the contract, the materials to be used and the test they must meet, methods of constructions in particular situations, the method of measurement of each item and the basis on which payment should be calculated.

对于合同所列的各项施工项目、需要的材料及其检验要求、具体条件下的施工方法、每个施工项目的验收方法以及付款计算的依据等，说明书中都应加以详细说明，这一点是十分重要的。

3. 拆译重组法

为汉语行文方便，有时可将英语原文的某一短语或从句先行单独译出，并利用适当的概括性词语或通过一定的语法手段把它同主语联系在一起，进行重新组织。

【例 6】 The load on a structure is subjects to are divided into dead loads, which include the weights of all the parts of the structure, and live loads, which are due to the weights of people, movable equipment, etc.

结构物受到的载荷分为静载和活载两种。静载包括该结构物各部分的重量，活载是由人群、可移动设备的重量等所引起的。

【例 7】 It is important that transportation engineers involved in the design and/or maintenance of highway pavement be familiar with the engineering properties of soils and the procedure through which the suitability of any soil for highway construction can be determined.

从事公路路面设计和(或)养护的交通工程师们要熟悉各种土的特性及其实验步骤，从而确定哪一种土适合于公路施工时用，这是很重要的。

# Chapter 12

# Traffic Engineering and Urban Transportation Planning

## Section A Traffic Engineering

### What is Traffic Engineering

Traffic Engineering is still a relatively new discipline within the overall bounds of civil engineering. It has nevertheless already been partially subsumed within the still newer but broader discipline of transportation planning. The disciplines are not synonymous though. Transportation planning is concerned with the planning, functional design, operation and management of facilities for any **mode** of transportation in order to provide for the safe, rapid, comfortable, convenient, economical and environmentally-compatible movement of people and goods. Within that broad scope, traffic engineering deals with those functions in respect of roads, road networks, **terminal** points, **abutting** lands and their relationships with other modes of transportation.

Those definitions, based on the 1976 ones of the Institute of Transportation Engineers are **compatible** with, but **in the light of** changing public attitudes are more complete than, the British Institution of Civil Engineers 1959 definition of traffic engineering, which is: 'That part of engineering which deals with traffic planning and design of roads, of **frontage** development and of parking facilities and with the control of traffic to provide safe, convenient and economical movement of vehicles and pedestrians.'

Traffic Engineering Manual of China defines traffic engineering as a technology discipline which researches the relationship of person, vehicles, road and environment in the highway traffic, establish **academic** method about traffic planning, design, control, management and their associated facilities, equipment, law, statute etc. in order to make the highway traffic safe, efficient, rapid and comfortable.

Recent years, its study are more and more extensive with the development of traffic engineering itself, on the other hand, it carves out new field with the progress of society, economy and technology. So the definitions of the discipline are becoming clearer: the **methodology** is developing continuously and becoming increasing scientific. The early '**rule-of-thumb**' techniques are disappearing.

### Elements of Traffic Engineering

Traffic engineering discipline is an important branch of transportation engineering. Anyone approaching the subject of traffic engineering already knows much about it. Anyone who walks, drives a car, rides in a car, takes a taxi, takes a bus or other else **traffic mode** has extensive

exposure to the systems that are the focus of the traffic engineer's profession. We can think of traffic engineering as measures or methods which deal with traffic problem in order to offer safe, rapid, comfortable and efficient movement of people and goods on streets or highway.

Objects in traffic engineering studies include roadways, vehicles, drivers, bikers, pedestrians and environment. Main elements in traffic engineering include such aspects as:

- Traffic studies—data collection and processing including **traffic volume**, demands, speeds, travel time, delays, accidents, **origins** and **destination.**
- Performance evaluation—set of criteria to measure the quality of traffic performance in terms of level of services or capacity.
- Facility design—functional and geometric designs, excluding structural elements.
- **Traffic control**—establishment of traffic regulation and their communication to the driver through signs, markings, and signals.
- Traffic operations—traffic organization, transit operation, curb management.
- TSM—Transportation Systems Management.
- ITS—Intelligent Transportation Systems.

**Connotation** of traffic engineering research deals with many fields such as engineering, enforcement, education, environment, energy, and it has relations with many factors such as economy, policy, system, **geography**, history etc. So it is a highly integrated science with natural and social sciences. Challenges that traffic engineers face at present include change in notion from increasing capacity to meet demand to managing the movement of vehicle and people; security of transportation and traffic engineers can't practice their profession in traditional ways.

## Traffic Problem

Traffic engineering is a young discipline because the problem is large and still growing. The road traffic is a basic of human production and survival, and vehicle is traffic tool for the convenience of our life. But it is becoming a public hazard of social. By derivation from the definitions of traffic engineering, the traffic problem can be considered from several aspects, all of which are interconnected. The operative words in the definitions are' … safe … convenient … economical… movement…'.We can think of these words as **embracing traffic flow**, traffic speed, traffic safety, and **amenities** for traffic, with which aspects traffic economics is closely **interwoven**; and throughout, the concern for environmental compatibility.

The traffic problem is of world-wide concern, but different countries are obviously at different stages in the traffic **escalation**. While a country has few roads and a relatively low standard of living there is little demand for motor transport and no real traffic problem. As soon as the country is opened up by a road system, the standard of living and the demand for motor transport both rise, gathering momentum rapidly. Eventually—the demand for cars, buses and lorries become satiated. The stage is known as saturation level.

Safety is a very serious traffic problem. Traffic accidents, injuries, and deaths continue as the major safety targets in transportation. Many international organizations have programs designed to address road safety problem and encourage developing countries to address the problem before it is too late. According to reports showing that since the motor vehicle road traffic accident deaths have

been recorded, all over the world the number of people killed in road traffic accidents have been more than 32 million. China's road traffic accidents are gradually increased with the development of the national economy, and large **fluctuations** happen with the **socio-economic situation** at that time. According to statistics, in 2006 a total of 379,781 traffic accidents happened in China, resulting in 89,455 deaths, 431,139 injures, and direct economic loss of 14.9 billion Yuan. Traffic accidents of road bring enormous life and property loss for social and human being. And with the development of economy and the growth in vehicle ownership, there is an upward trend in the accident; it has become an important social problem. Furthermore, traffic problems also include environment pollution, **consumption** of a large number of energy and land and so on.

The growth in vehicle ownership also is one part of the overall traffic problem. Obviously, if a country has unlimited roads of extreme width, the traffic problem would not rise. But no country in the world could meet this requirement: apart from anything else, it would not make economic sense.

## Three Possible Solutions

The basic problem of traffic is therefore simply an ever-increasing number of vehicles seeking to use too little road space. So the solution to the problem is also a not-too-difficult choice from three possibilities:

(1) Build sufficient roads with sufficient width to cope with the growth in vehicle.

(2) Restrict the demand for road by restricting the numbers of licensed vehicles.

(3) A compromise between (1) and (2) : build some extra roads, using them and the existing road network to their full potential, and at the same time apply some restraint measures, limiting the increase in demand as far as possible.

It will be appreciated that the problems of traffic engineering are most pressing in urban areas. We shall concentrate on dealing with urban traffic problems and techniques, looking at rural problems on passing. And the traffic engineer should be checking to ensure that he is at least not damaging the environment, and is preferably improving it. Traffic engineering today, more than ever, is about improving the quality of life.



## Words and Phrases

mode [məud] *n.* 方式，模式，样式，风格，时尚
terminal ['tə:minəl] *n.* 终点站，终端；*adj.*末端的，终点的，极限的
compatible [kəm'pætəbl] *adj.* 一致的，兼容的，协调的
frontage ['frʌntidʒ] *n.* 正面，前面
academic [ˌækə'demik] *adj.* 纯理论的，学术性的
methodology [ˌmeθə'dɔlədʒi] *n.* 方法学，方法论，一套方法
origin ['ɔridʒin] *n.* 起点，来源
destination [ˌdesti'neiʃən] *n.* 目的地，终点
connotation [ˌkɔnəu'teiʃən] *n.* 内涵，意义
geography [dʒi'ɔgrəfi] *n.* 地理(学)，地形，地势
embrace [im'breis] *vt.* & *vi.* 包括，包含
interweave [ˌintə'wi:v] (interwove，interwoven) *vt.* 交织，交叉

amenity [ə'mi:niti] *n.* 舒适，适宜，愉快，乐事(趣)
escalation [ˌeskə'leiʃən] *n.* 不断增加，逐步上升，扩大，增加
fluctuation [ˌflʌktju'eiʃən] *n.* 波动，起伏
consumption [kən'sʌmpʃən] *n.* 消费，消耗，消费量
substantial [səb'stænʃəl] *adj.* 坚固的，实质的，真实的，充实的
in the light of 按照，根据，由于
carve out 创造出，雕刻出，开拓
rule-of-thumb 经验法则(方法)
traffic mode 交通方式
traffic volume 交通量
traffic control 交通控制
traffic flow 交通流
saturation level 饱和度，饱和状态
socio-economic situation 社会经济状况，社会经济形势

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Connotation of traffic engineering research deals with many fields such as engineering, ________, education, ________, ________, and it has relations with many factors such as economy, ________, system, ________, history etc.

2. The traffic engineer should be checking to ensure that he is at least not ________ the environment, and is preferably ________ it.

3. Traffic engineering is a technology discipline which research the relationship of person, ________, road and ________ in the highway traffic.

Ⅱ. Translate the following passages from English into Chinese.

The institutional structure for transportation has usually been considered from the public-sector perspective. That is, the major providers of transportation, and the most important actors in the planning process, were thought to be public agencies and officials. However, the opportunities for transportation in most urban areas include a variety of services, many of which are provided by private-sector groups. Many employers are actively involved with employee ride-sharing programs; land developers are concerned about transportation access to developed sites; private-sector groups such as taxi companies, bus firms, and school-bus operators can provide substantial transportation services; and business groups (such as chambers of commerce) can influence the policies and the planning process of government agencies.

When considering the flow of traffic along a highway three descriptors are of considerable significance. They are the speed and the density or concentration, which describe the quality of service experienced by the stream; and the flow or volume, which measures the quantity of the stream and the demand on the highway facility. Numerous observations have been carried out to determine the relationship between any two of these parameters for, with one relationship established, the relationship between the three parameters is determined.

## Section B Traffic Planning

Traffic planning is an important **front-end** engineering in the **infrastructure** construction of the city traffic. It is also the fundamental solution to the traffic problem and the effective means to obtain the best value of transport work. It will have **far-reaching** influence on city development in the future.

Traffic planning is a series of actions planned to guide traffic, that is, how to prompt a variety of goals of planners, and how the objectives will put into practice. Because the planning of transportation is only one aspect of the overall planning process which affects the quality of life in a developed society, the provision of transport facilities is dependent on the overall economic resources available. It is dependent on the value that is placed on such factors as environmental conditions; for some transport facilities are considered to **detract** from the quality of the environment and others can be considered to improve the environment. Land use and traffic planning are also closely connected because the demand for travel facilities has often stimulated land-use activity.

Urban traffic planning steps are: ① provide goals and objectives; ② survey and collect information; ③ analysis data and derive **mathematical models**; ④ forecast; ⑤ preparation of alternative plans; ⑥ testing and evaluation; ⑦ **implementation**.

Traffic survey is a **precondition** and foundation for traffic planning. It mainly provides comprehensive, systematic, real and reliable reference materials and basic data for shaping traffic planning. The main reason for undertaking a traffic survey is to provide an objective measure of an existing situation. A survey is to take an inventory of the trip making pattern as it exists at the present time, together with details of the travel facilities available and the land-use activities and socio-economic factors that can be considered to influence travel. **Origin and destination surveys** are one of those surveys. An O-D survey is necessary where it is **anticipated** that traffic will be drawn from a number of existing routes onto a new or improved road. By means of this type of survey it is possible to estimate the number of drivers traveling on each of the existing routes who will choose to use the new road in future. The O-D survey obtains, in addition to a **straightforward** count of vehicles on each road, further information concerning the place of origin and destination of each journey and the location of any intended intermediate stops within the survey area. The origin of the journey is in this instance the last fixed point of call prior to entering the area covered by the survey and the destination is the nest point of call after leaving the area. These are not necessarily the same as, and must not be confused with, the origin and the destination of the overall journey.

While the decision to make a trip is a complex process based on the availability of destinations, the travel facilities, the cost of travel and the journey purpose, it is usual to divide model building into four interconnected processes.

① **Trip generation**, which is the first step in the conventional four-step transportation forecasting process. It widely used for forecasting travel demands. It predicts the number of trips originating in or destined for a particular traffic analysis zone. In general, different land-use layout, different natures of land use and different land-use intensity correspond to different traffic

generation. Trip generation attempts to determine the connection between trip making and land-use factors noted in the planning inventory.

② **Trip distribution**, which determine **the pattern of trips** between the zones. Trip distribution is a model of the number of trips that occur between each origin zone and each destination zone. It usually occurs through an allocation model that splits trips from each origin zone into distinct destinations. That is, there is a **matrix** which relates the number of trips originating in each zone to the number of trips ending in each zone. Trip distribution uses the predicted number of trips originating in each origin zone (**trip production** model) and the predicted number of trips ending in each destination zone (**trip attraction** model). The model trip distribution can then be compared to the actual distribution to see whether the model produces a reasonable **approximation**.

③ **Modal split**, by which a decision is made as to which travel mode a trip maker will use. Transportation modes include walking, bicycling, public transport, and using a vehicle (either as a driver or passenger) and so on. The trip-generation and trip-distribution steps may or may not be concerned with the problem of converting person-trips into automobile trips or transit passenger trips. Where mode choice is essential, several procedures are available to determine the split either before or after the trip-distribution step. Trip diversion based on travel-time differences between modes is the basis for some methods, but it is being **supplanted** by techniques relying heavily on trip-maker or household characteristics.

④ **Traffic assignment**, which assign the numbers and modals of trip to the actual route in all traffic areas. At this stage the number of trips and their origins and destinations are known but the actual route through the transportation system is unknown. This process of determining the links of the transportation system on which trips will be loaded is known as traffic assignment. There are three main methods by which the assignment may be made. These are: **all-or-nothing assignment**, **capacity restrained assignment** and **multipath proportional assignment**. An assignment problem is the distribution of traffic in a network considering a demand between locations and the transport supply of the network. Assignment methods are looking for a way to model the distribution of traffic in a network according to a set of constraints, **notably** related to transport capacity, time and cost.

With confidence in the ability of the developed models established, it is then possible to forecast the travel needs of future land use and transport plans. Arriving at an optimum solution is however an **intuitive** process because the planning process can only predict the likely trip-making which will arise if the plan is implemented. Alternative plans may be evaluated, on a limited basis, by the estimation of the costs and benefits which arise if the plan is carried out.

With the continuous development of the **urbanization** process and motorization, the performances of urban traffic problems are more and more prominent. The role of traffic planning is more and more important, and more and more attention.

## Words and Phrases

infrastructure ['infrə,strʌktʃə] *n.* 下部构造，基础设施，基础结构
detract [di'trækt] *vi.* 毁损，贬低，减损

implementation [ˌimplimenˈteiʃən] *n.* 执行，实施，实现
precondition [ˌprikənˈdiʃən] *n.* 前提，先决条件
anticipate [ænˈtisipeit] *vt.* 预感，期望
straightforward [streitˈfɔːwəd] *adj.* 简单的，易懂的
matrix [ˈmeitriks] *n.* 矩阵，岩石，矿脉
approximation [əˌprɔksiˈmeiʃən] *n.* 近似值，接近，走近
supplant [səˈplɑːnt] *vt.* 排挤掉，取代
notably [ˈnəutəbli] *adv.* 显而易见地，明显地
intuitive [inˈtjuitiv] *adj.* 有直觉力的，凭直觉获知的
urbanization [ˌəːbənaiˈzeiʃən] *n.* 都市化，文雅化
front-end 前端的
far-reaching 深远的
mathematical model 数学模型
origin and destination survey 起讫点调查
trip generation 出行生成
trip distribution 出行分布
the pattern of trip 出行方式
trip production 出行产生
trip attraction 出行吸引
modal split 交通方式划分
traffic assignment 交通分配
all-or-nothing assignment 全有全无分配法
capacity restrained assignment 交通容量限制分配法
multi-path proportional assignment 多路径概率分配法

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. ________ is the first step in the conventional four-step transportation forecasting process.

2. An O-D survey is necessary where it is ________ that traffic will be drawn from a number of existing routes onto a new or ________ road.

3. There are three main methods by which the assignment may be made. These are: all-or-nothing assignment, ________ assignment and ________ assignment.

4. In general, different land-use ________, different ________of land use and different land-use ________correspond to different traffic generation.

Ⅱ. Translate the following passages from English into Chinese.

To be effective and responsive, transport planning must satisfy three main requirements. First, it must ensure that a sound economic and financial capability exists to support transport improvements, and that resources are used efficiently and transport assets maintained properly. This corresponds to the concept of economic and financial sustainability. Second, it must generate the greatest possible improvement in the general quality of life, not merely an increase in traded goods

and services, with externalities taken into account fully when public or private decisions regarding transport improvements are made. This relates to the concept of environmental and ecological sustainability. Third, the benefits that transport produces must be shared equitably by all sections of the community. This pertains to the concept of social sustainability. In all this, economical and financial considerations play a pivotal role. Rigorous economic appraisal of investments in transport infrastructure, appropriate pricing for its efficient use, and adequate financial and fiscal provisions for its maintenance remain crucial. From an operational standpoint, environmental sustainability is concerned with the promotion of livable settlements and mitigation of unavoidable environmental and ecological impacts of transport development.

## Section C Public Transport Priority

**Traffic jams** have now become a common problem in many cities across China. It is rapidly becoming one of the major problems **constraints** of urban development in our country. China's **urban** residential population of high density and limited road space has been decided that giving priority to the public transport is an inevitable choice which can ease traffic jams situation in implementing **urban transport strategy** for sustainable development. Public transport priority has to be seen in the **context** of an overall urban transport strategy with objectives which include not only improved bus (or tram) operation and restraint of **car-borne** commuting but also an enhanced environment for residents, worker and visitors. Measures proposed must serve all objectives and yet also be **demonstrably cost-effective** and enforceable.

One objective of public transport priority techniques can be improvements in service regularity, which usually means alignment with **nominal** time-tables and/or headways. A regular service **guarantees** a good level of **transport capacity** (expressed in terms of "passengers per hour"): the major goal of transport management. Moreover it makes service planning easier, reduces the time lost by passengers at bus or **tram** stops, increases user satisfaction and reduces driver stress. Typical sources of service irregularity are: user demand variations, traffic **congestion** and **traffic signal control**. The reduction of the disturbance caused by traffic signal control and the exploitation of priority features constitutes a real success. A second important objective is a gain in commercial speed. Traffic signal priority contributes to the reduction of vehicle journey times and can produce greater transport capacity or a reduction in the number of vehicles required to provide the service. A third objective, that is becoming increasingly important for transport management, is the reduction of pollution. A smaller number of stops at traffic signals and less time lost in **queues** are direct effects of traffic signal priority and advanced traffic signal control techniques. The final important objective is that of a more **rational** use of energy.

Bus priority methods may take the following forms:

(a) Facilities for stopping on freeways and other roads where parking, loading or unloading is prohibited.

(b) **Authority** to make right turns (or left turns where the rule of the road is to keep to the right) **barred** to other traffic for the purpose of reducing conflicting vehicular movements.

(c) Activation of traffic light in their favor by buses by means of special equipment placed on the vehicle.

(d) Special bus lanes (usually the nearside lane) which allows buses (in single file) to proceed ahead of other road users held in traffic blocks. (The **practicability** of a bus lane is dependent of course on there being an adequate width of road to allow at least a second lane for general traffic.)

(e) **Contra-flow** operation along what have otherwise become **one-way streets**. This is, in effect an extension of the **bus only lane** principle but against the normal traffic flow.

(f) The use of through routes denied to other traffic by the provision of special "bus gates" being, in effect, no entry signs which buses are permitted to pass.

(g) The use of roads denied to all other traffic; in other words, **bus only roads**.

(h) Special provision for buses built into a system of urban traffic control. This could take the form of special computer programming for selected bus routes, separate and unrestricted access for buses on to a highway for which other traffic might have to queue and participation by bus operators in the control of such schemes.

Those typical bus priority measures can be grouped into four main categories:

(1) Bus lanes and busways

This measure mark out a lane of carriageway for use by buses and any road with two lanes (on each side) is a potential **candidate**. Bus lanes are operated usually at peak times. Its advantage is that existing road without alteration is used; disadvantage is it fails if law enforcement is poor.

(2) Traffic signal control

It includes: signal rephrasing for passive bus priority; queue relocation and traffic metering; overlap phases; **pre-signals** and bus advance areas; selective vehicle detection-active bus priority.

(3) Bus stop improvements

In order to provide for passenger convenience, and to operate a safe and efficient transportation system bus stop improvements request has established.

(4) Traffic and parking management measures

The above-mentioned categories are considered separately, but in practice the design for a bus route **corridor** will draw on measure from all these categories.

In large cities such as Beijing, Shanghai, Guangzhou and Shenzhen, public transportation situation has worsened in recent years, due to the large urban population and numerous vehicles in these cities. In light of this, the task of improving the public transportation system in large cities has been included in China's Eleventh Five-Year Plan for Social and Economic Development, as part of an important strategy to solve traffic jam in big cities, to realize the goal of building resource conservation cities and promoting a **harmonious society**. Experts stated that promoting **BRT** in large cities can help better utilize transport resources and solve traffic jam problem. The measure is in line with Chinese national situation.



## Words and Phrases

jam [dʒæm] *n.* 拥挤，堵塞，窘境

constraint [kən'streint] *n.* 强制，限制，约束，局促

urban ['əːbən] *adj.* 城市的

strategy [ˈstrætidʒi] *n.* 策略，计谋
context [ˈkɔntekst] *n.* 上下文，文章的前后关系
commute [kəˈmjuːt] *vt.* 交换，抵偿，减刑
demonstrably [ˈdemənstrəbli] *adj.* 可表明的，显然的，不言而喻的；*adv.*确然
nominal [ˈnɔminəl] *adj.* 名义上的，有名无实的
guarantee [ˌgærənˈtiː] *vt.&n.* 保证，担保
tram [træm] *n.* 有轨电车，电车轨道
congestion [kənˈdʒestʃən] *n.* 拥塞，堵车，充血
queue [kjuː] *n.* (人或车辆)行列，长队
rational [ˈræʃənl] *adj.* 理性的，理智的，合理的，出于理性的
authority [ɔːˈθɔrəi] *n.* 权威，专家，权力，当局
barred [bɑːd] *adj.* 有木栅的，隔绝的，被禁止的
practicability [ˌpræktikəˈbiliti] *n.* 有实行可能，实用性
candidate [ˈkændideit] *n.* 申请求职者，候选人，报考者
corridor [ˈkɔridɔː] *n.* 走廊，通道
public transport priority 公交优先
traffic jam 塞车，交通拥堵
urban transport strategy 城市交通战略
car-borne 车载的
cost-effective 有成本效益的
transport capacity 运输能力
traffic signal control 交通信号控制
contra-flow 对流，逆流
one-way street 单向交通
bus only lane 公交专用车道
bus only road 公交专用道路
pre-signal 预信号
harmonious society 和谐社会
BRT=bus rapid transmit 快速交通



## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Typical bus priority measures fall into four main categories: bus ________ and busways; traffic ________ control; bus stop ________; traffic and parking ________ measures.

2. China's urban residential population of ________density and ________ road space has been decided that giving priority to the public transport is an inevitable choice which can ease ________ situation in implementing urban transport strategy for sustainable development.

3. Traffic signal priority contributes to the ________of vehicle journey times and can produce ________ transport capacity or a ________in the number of vehicles required to provide the service.

Ⅱ. Translate the following passages from English into Chinese.

Techniques used to improve transit include express bus services, shuttle services from fringe parking areas to downtown, internal circulation in low-density areas, improved flexibility in route scheduling and dispatching, simplified fare collection procedures, park-and-ride facilities, shelters, bus stop sign, bus fleet modernization, and improved passenger information services.

Methods of priority treatment for buses are sometimes applicable to streetcar operation. This applies particularly to signal priority measures and exclusive use of streets in downtown areas. Light rail transit can offer platform speeds and track capacities that are only moderately lower than heavy rail transit. More direct service with branch or parallel lines can often be provided: stops may be located more accessibly and spaced more closely to reduce walking distances. Thus overall door-to-door travel times for urban trips up to perhaps 10mi (16km) may be in the same range as those provided on fully grade-separated urban rapid transit facilities. Attractive linear park treatments, such as along St. Charles and Carrollton Avenues in New Orleans and Beacon Street in Boston-Brookline, can provide additional amenities along and in the streetcar right-of-way located in street medians.

## 参 考 译 文

### 第 12 章　交通工程及城市运输规划

Section A　交通工程

**什么是交通工程学**

交通工程学在整个土木工程领域内还是一个相当新的学科。然而它已经部分并入了更新更广的运输规划学科内，这两个学科不是同义的。运输规划是关于各种运输模式的设施规划、功能设计、运营与管理，以便提供安全、快速、舒适、方便、经济，与环境协调的人与货的流动。在此广阔的范围内，交通工程研究道路、道路网、终点，毗邻土地及其与其他运输模式的关系等方面的功能。

上述的定义是基于 1976 年交通工程师学会的定义提出的，并与其相一致，但是随着公众认识的不断发展，英国土木工程师学会 1959 年对交通工程学的定义相比来讲是更完整的："交通工程学涉及交通规划和道路设计、停车设施的研究与发展，以及为了车辆和行人提供安全、方便和经济运行的交通控制。"

我国《交通工程手册》给出的定义认为交通工程学是一门技术科学，它研究道路交通中人、车、路、环境之间的关系，建立交通规划、设计、控制和管理的理论方法，以及相关设施、装备、法律和法规等，使道路交通安全、高效、快捷、舒适。

近年来，由于交通工程学本身的发展，研究内容日趋广泛，另一方面随着社会、经济与科学技术的进步，开拓了交通工程学的新领域。因此，交通工程学的定义变得更加清晰，该方法学是不断发展和日益壮大的科学，早期单凭经验的技术方法正逐渐消失。

**交通工程学的内涵**

交通工程学是运输工程学的一个重要分支。任何一个接触交通工程的人都对此了解很多。走路的行人、驾驶汽车的司机及其乘客、乘坐出租车的乘客、乘公共汽车的人以及采取其他任何交通方式出行的人都对交通系统有广泛的接触，其研究重点就是交通工程专业。我们可

以把交通工程学看成是一系列的措施和方法，其目的是解决交通问题，为路上的人或物提供安全、快速、舒适、高效的运行。

交通工程学的研究对象包括道路、车辆、驾驶员、骑自行车的人、行人和环境等。其主要的研究内容包括：

- 交通调查——数据的收集和处理，包括交通量、交通需求、行车速度、运行时间、延误、交通事故、起终点调查。
- 性能评估——根据服务水平或通行能力制定评估交通性能质量的标准。
- 设施设计——功能和线形设计，不包括结构要素的设计。
- 交通控制——制定交通规则，通过交通信号、标线和标志向驾驶员传递信息。
- 交通运营——交通组织，过境管理，限制管理。
- TSM——交通系统管理。
- ITS——智能交通系统。

交通工程学研究的内容涉及工程、执法、教育、环境、能源等许多领域。同时它还与诸如经济、政策、制度、地理、历史等许多因素有关。因此，它是一门集自然科学与社会科学于一身的综合性科学。交通工程师当前面临的挑战是观念的转变，即从提高通行能力来满足交通需求到管理车辆和人们的出行来降低需求量；运输的安全性以及无法用传统的方法体现他们的专业实践。

**交通问题**

交通工程学是一门年轻的学科，因为还存在着大量的不断发展的问题。道路交通是人类生产和生存的基础，并且车辆作为交通工具方便了我们的生活，但它同时也成为社会公害。从交通工程学的定义出发，交通问题可以从几个方面考虑，所有这些都是相互关联的。定义中关键的词有：安全、方便、经济、运行。我们可以认为这些词包含交通流、交通速度、交通安全、交通设施，这几方面与交通经济是密切相关的，并且自始至终还要考虑环境的可持续发展。

交通问题是全世界广泛关注的问题，但是显然，不同的国家处于交通问题发展的不同阶段。如果一个国家拥有很少的道路和相对较低的生活水平，那么他们就几乎没有汽车运输的需求，更谈不上真正的交通问题。一旦这个国家开始发展其道路体系，那么他们的生活水平和汽车运输的需求都会上升，并且发展势头迅猛。最后，对汽车、公共汽车和大车的需求被充分满足，该阶段被称为饱和阶段。

安全是一个非常严重的交通问题。交通事故、受伤人数、死亡人数一直是交通运输中主要的安全指标。许多国际组织已制订计划旨在解决道路安全问题，并鼓励发展中国家在来得及的时候解决好这一问题。据报道，自从机动车道路交通事故死亡人数被统计以来，全世界因交通事故死亡的人数超过 3200 万。随着国民经济的发展，中国的道路交通事故也呈上升趋势，并且伴随当时的社会经济状况有大幅的波动。据统计，2006 年中国共发生了 378,781 起交通事故，造成 89,455 人死亡，431,139 人受伤，直接经济损失 14.9 亿元。道路交通事故给整个社会和人类带来巨大的生命和财产损失。随着经济的发展和汽车拥有量的增长，交通事故呈上升趋势，它已成为一个重要的社会问题。此外，交通问题还包括环境污染、能源和土地的大量消耗等。

汽车拥有量的增长也是全部交通问题的一部分。显然，如果一个国家拥有无限制的道路宽度，交通问题将不会上升，但是，世界上没有一个国家能满足这一要求，且不说别的什么理由，经济上就是没有意义的。

**三种可能的解决方案**

交通的基本问题可以简单地归结为：不断增长的汽车数量与太小的道路空间之间的矛盾。因此，解决这个问题有以下三种可能，这也是一个不太困难的选择：

(1) 修建足够多的道路和足够宽的路面，以适应汽车数量的增长；

(2) 通过限制汽车牌照来减少对道路的需求；

(3) (1)和(2)折中的办法：多修建一些道路，充分发挥它们和现有的路网的潜力，同时，采取一些限制措施，尽可能地限制需求的增长。

我们应该意识到城市地区的交通工程问题是最紧迫的，目前应该集中精力处理城市交通问题，关注农村交通问题。同时，交通工程师应不断检查，以确保交通没有破坏环境，而是在改善环境。今天的交通工程比以往任何时候更有利于提高生活质量。

Section B　交通规划

交通规划是城市交通基础设施建设中的一个重要前期工程，它也是解决交通问题的根本措施，获得交通运输工作最佳效益的有效手段,它对城市今后的发展有深远的影响。

交通规划是有计划地引导交通的一系列行动，即规划者如何提出各种目标，又如何将目标付诸实施的方法。因为交通规划是现代发达社会中，与生活水平有关的总体规划程序中的一个重要组成部分，因此交通设施的供应情况依赖于整个社会上可用的经济资源。它还取决于诸如环境条件等因素的标准，有一些交通设施被认为有损于环境的质量，有的则被认为对环境有所改善。交通设施的需求常常刺激土地的开发利用，因此，土地利用和交通规划两者之间是紧密相连的。

城市交通规划的步骤是：①提出宗旨和目标；②调查和收集资料；③分析数据并推导数学模型；④预测；⑤准备规划方案；⑥测试和评估；⑦实施。

交通调查是进行交通规划的前提和基础，主要是为制定交通规划提供全面、系统而又真实可靠的实际参考资料和基础数据。进行交通调查的一个最主要的原因就是对目前的局势进行客观的衡量。调查是为了整理出一份当前出行方式的清单，以及可利用的交通设施的详细资料和影响土地使用活动和社会经济因素等情况。起迄点调查是交通调查的内容之一。当调查范围内的路网交通转移到其他路网而进行交通预测时，O-D 调查是必要的。通过此项调查，有可能估计出在现有路网上通行的而随后会选择新路线的车辆的数量。O-D 调查除了能够直接获得每条道路上的车辆数量以外，还可以进一步获得每段行程的起始地和目的地以及在调查范围内的任何打算中途停靠的地点的信息。在此调查中，行程的起点要求是进入调查区域之前最后一个固定点，而旅途的目的地则是离开该区域后的落脚点。整段行程的起点和终点不一定相同，决不能混淆。

决定出行是个复杂的过程，它将以到达目的地的方便程度、出行所使用的交通工具、出行成本，以及出行目的等因素为依据。通常把模型建立划分为四步相互关联的步骤。

① **交通生成**，它是常规的四步交通预测法中的第一步，广泛地应用于预测交通需求。用于预测特定交通分析区域内作为交通起点和终点的数量。一般而言，不同的土地利用布局，不同性质的土地使用，不同的土地利用密度对应于不同的交通生成。交通生成用以确定出行生成和规划资料清单中所注用地因素之间的关系。

② **出行分布**，用以确定各交通区间的出行方式。出行分布是关于发生在每个起点和每个终点之间的交通数量的模型。通常出行分布通过分配模型产生许多从起点到不同的终点的交通流。也就是说，有一个矩阵涉及每个子区作为起点交通和终点交通的数量。出行分布用来预测每个起点区域(出行产成模型)的交通发生量和每个终点区域(出行吸引模型)的交通吸引

量。交通分布模型结果可以与实际分布情况进行比较，来决定模型得出的是否是合理的近似值。

③ **交通方式划分**，用以决定一个出行者将采用何种交通方式出行。出行方式包括步行、自行车交通、公共交通和小汽车交通(包括驾驶员与乘客)。交通生成和出行分布阶段可能会也可能不会涉及从步行换乘机动车的换乘次数或者是过境交通的数量。交通方式的选择是至关重要的，有许多程序用以确定交通的分布，无论是在出行分布这一步之前还是之后。基于出行方式间不同出行时间的交通转换是许多划分方法的基础，但它正在被严重依赖于交通产生者或住户的特征的方法所取代。

④ **交通分配**，是在整个交通区域内将交通数量和交通方式分配给实际路线。在现阶段，出行次数和它们的起终点虽然已经知道，但是在交通系统中所经过的实际路线还不明确。把出行分配到交通系统路线上的程序就叫做交通分配。交通分配方法有三种，即：全有全无分配法，交通容量限制分配法，多路径概率分配法。分配问题是路网中的交通分布，需要考虑地点之间的交通需求和路网的运输供应情况。分配方法希望是交通网中根据一系列的制约因素而得出的交通分配模型，尤其是相关的运输能力、时间和成本。

如果确信已经建立的各种模型的分析能力是可靠的，就有可能预测未来土地利用和交通规划的交通需求程度。但是，所能达到的一个最优解决方案，仍然是一个直觉过程，因为规划过程只能预估未来实现规划可能发生的出行生成情况。不同规划方案则多是按照预估的费用和收益来进行评价。

随着城市化的进程和机动化的不断发展，城市交通问题表现的越来越突出，交通规划的作用越来越重要，也越来越受到重视。

Section C　公交优先

在中国交通拥挤已经成为许多城市的一个共同的问题，它正迅速成为制约我国城市发展的重大问题之一。我国高度密集的城市居住人口和有限的道路空间资源决定了优先发展公共交通是缓解我国交通拥挤形势实施城市交通可持续发展战略的必然选择。公交优先应被视为整个城市交通战略的一部分，其目标不仅是改善公交(或电车)的运行和限制小汽车通勤交通，而且也是为居民、工作人员和游客提供一个更好的环境。建议采取的措施必须有助于目标的实现，同时也确实是经济的和可实施的。

公交优先的一个目标是改善服务的规律性，通常指的是与名义上的时间表及其进度相符合。有规律的服务保证了良好的运输能力(体现在“乘客每小时” )，即主要的管理目标。此外，它使服务计划更容易实现，减少了乘客在公共汽车站或电车站的候车时间，提高了用户的满意度并且降低了驾驶员的压力。服务不规律的有代表性的原因包括：用户需求的改变、交通拥堵和交通信号控制。交通信号控制是为了减少冲突而公交优先信号的应用实现了真正意义上的成功。第二个重要的目标是提高旅行速度。交通信号优先有助于减少车辆的行车时间，并且能为产生更大的运输能力和减少小汽车的数量提供帮助。公交优先的第三个目标是不断提高它在运输管理中的重要地位，同时在减少污染方面也发挥着日益重要的作用，更少的车停在信号前和排队时间的大大减少将直接影响交通信号优先权和先进的交通信号控制技术。最后一个重要目标是更合理地利用能源。

公交优先的方法可以采取下列形式：

(a) 在高速公路和其他禁止停车和装卸货物的道路上为公交车修建停车设施。

(b) 为了减少冲突而禁止其他交通方式右转的地方公交车可以右转(或者是在禁止左转的地方可以左转)。

(c) 通过车内放置的特殊设备激活信号灯，使其有利于公交车辆的通行。

(d) 公交车专用道(通常设在靠近人行道一侧)允许公交车(形成一列纵队)比其他道路使用者优先通过。(公交车专用车道的可行性依赖于是否存在足够宽的道路，至少应有另一条车道为其他交通所用。)

(e) 允许公交车在实施单向交通的街道上逆向行驶。这实际上是公交专用车道原理的扩展，只是与正常交通流方向相反。

(f) 在禁止其他交通方式通过的路线上利用特殊的“公交入口”的设置，在有禁止驶入标志的地方允许公交车通过。

(g) 修建禁止其他任何车辆通行的道路，即公交车专用道路。

(h) 在建成的城市交通控制系统中为公共汽车做特殊的规定，允许公交运营商参与制定这些规定，可能采取的形式是用特殊的计算机程序来选择公交线路，在其他交通需要排队通行的道路上公交车可以单独地不受限制地通过等。

这些典型的公交优先措施可以归纳为以下四大类：

(1) 公交专用车道

这项措施是在道路上画出一条行车道供公交车使用，任何具有单向两车道的道路都具备画出公交专用道的条件。公交专用道通常是在高峰时段投入使用。它的优点是充分利用现有道路；缺点是如果执法力度不够就容易失去作用。

(2) 交通信号控制

它包括：为有优先通行权的公交车改变信号；排队车辆变换车道和交通测定；相位的相对重叠；预信号和公交待停区；选择性的车辆检测使公交优先。

(3) 公交站点的改善

为了给乘客提供方便，也为了使运输系统能够安全高效的运营，制定公交站点的改善要求。

(4) 交通和停车管理措施

上述几个类别经常被人们单独考虑，但在实践中公交线路的设计将考虑所有类别中的措施。

许多大城市的公共交通状况近年来已经恶化，如北京、上海、广州、深圳，由于这些大城市人口多车辆多。鉴于此，改善大城市公共交通系统的任务已被列入我国社会和经济发展十一五规划，作为一项解决大城市交通拥堵的重要战略，要实现的目标是节约城市的建设资源和促进社会和谐。专家指出，在大城市发展快速公交系统可以帮助更好地利用运输资源，解决交通拥堵问题。这项措施是符合中国国情的。



## Grammar：专业英语的翻译技巧(Ⅸ)——特殊句型的译法(1)

### Translation Skills of English for Professional Purpose Ⅸ—Translation of Special Sentence Pattern(1)

Ⅰ.被动句的翻译(Sentences of Passive Voice)

英语被动句出现的频率大大超过汉语“被”字句使用的频率。英语文章中没有被动句是不可想象的。英语的主动句和被动句是对同一件事的两种看法，并不牵涉说话人或当事人对整个事件的评价或受事者是否遭受不幸。事实上，英语被动句可以避免指出施事者，可以用来表示客观的态度。G. 利奇和 J. 斯瓦特维克所著的《交际语法》中提到严肃正式的英语有一种客观的风格，而这种风格的特点之一就是被动句。

下面介绍几种常用的翻译方法：

1. 译成汉语被动句

两种语言相比，英语是更为形式化的语言，而汉语是更为分析性的语言，词序、语序显得尤为重要。英语中被动语态的句子，常常可译成汉语的被动句，这时可加“被”、“由”、“所”、“把”等词译出。也可不加任何词直接译出。

**【例 1】** Asphalt was originally used only as a covering.

沥青最初仅被用来做铺面。

**【例 2】** A foundation can be built in one of many different materials.

基础可以用多种不同的材料来修建。

**【例 3】** Durability is greatly influenced by concrete permeability.

混凝土的耐久性受其渗透性影响非常大。

**【例 4】** Intellectual self-discipline is required to avoid ignoring important alternatives, uncertainties, decisions, or trade-offs.

为避免忽略重要方案、不确定因素、决策及可替代的关系，需要有明智的自律。

**【例 5】** Once it has been decided that certain factors are peripheral—that they don’t create the dilemma or affect its essence—that can be safely ignored at least until the results of the first cut analysis suggest that one or two of them may, in fact, be important.

一旦确定某些因素是外围性的——确定它们并不产生困惑或没有实质性作用——那么它们就完全可以(被)忽略，只有在第一次分析的结果表明其中一两个可能很重要时，才应另当别论。

**【例 6】** A new design method for bituminous roads was published in 1984.

沥青路面新的设计方法是 1984 年公布的。

**【例 7】** To the other extreme, if the industry is dominated by a single firm, there will be potential to earn monopoly profits.

在另一个极端，如果产业被一家公司垄断，就有可能赚到垄断利润。

英语中的被动语态有时并不强调动作，而强调状态，这时可用汉语“是……的”这一框架来表达。这种表达灵活简便，言简意赅，新颖独特。

**【例 8】** As Simon’s principle of bounded rationality makes clear, however, such an ideal rationality can never be attained because of the limits of time, information, and intellectual capacity.

然而正如西蒙的有限理性原则所明确阐明的，由于受时间、信息和智力的限制，这种理想要求是永远达不到的。

2. 译成汉语主动句

当英语被动句中的主语为无生命的名词，且句中一般没有由介词 by 引导的行为主体时，这种句子常常可译成汉语的主动句。当被动句中有地点状语、由介词“by”引导的方式状语及“from”等表示的其他状语时，有时可把这种状语译成主语，将介词省略，而把原主语译成宾语。如果英语中某些要求宾语及宾语补足语的动词为被动语态，翻译时往往可在其前加“人们”、“大家”、“我们”等含有泛指意义的词做主语，而把原句中的主语译成宾语。

【例 9】 In certain circumstances, a decision maker may have some statistical data available that can be used to calculate these probabilities.

在某些情况下，决策者可得到一些统计数据来计算这些结果。

【例 10】 It is well known that the compass was invented in China four thousand years ago.

众所周知，中国在 4000 年前发明了指南针。

【例 11】 It has been known for a long time that it is a first relationship between the heart and the liver.

长期以来，大家知道心脏和肝脏的关系是最重要的。

【例 12】 Considerable use will be made of these experimental data.

这些实验数据将得到充分利用。

3. 译成汉语无主句

英语中许多被动语态的句子，往往可译成汉语中的无主句，这时被动句中的主语就译成无主句中的宾语。英语句子中没有主语是不行的，而汉语却可以。

【例 13】 Specialties in colleges and universities will be readjusted and teaching methods improved.

要调整高等院校的专业设置，改进教学方法。

【例 14】 In 1985, a total of 20,000 postgraduate students was admitted.

1985 年共招收研究生 2 万人。

【例 15】 Most important, an updated operation plan being set to satisfy the current market, and the consequences of taking various actions are known ahead of time, minimizing costly and disruptive surprises.

最为重要的是，修订运营计划是为了满足当前的市场需要，因此必须事先知道各种措施所产生的后果，这样就可以最大限度地减少代价高昂的和破坏性的意外事件。

【例 16】 Attempts are also being made to produce concrete with more strength and durability, and with a lighter weight.

目前仍在尝试生产强度更高、耐久性更好，而且重量更轻的混凝土。

Ⅱ. 复合句的翻译(Compound Sentence)

根据从句在主句中所充当的不同成分，复合句可分为名词性从句、定语从句和状语从句三类。本篇重点介绍定语从句的翻译。

1. 名词性从句

名词性从句包括主语从句、宾语从句、表语从句、同位语从句四种。

【例 1】 That electricity is a form of energy is known to all.

电是能的一种形式，这是众所周知的。(主语从句)

【例 2】 I want to know whether heat energy is a form of motion.

我想知道热能是否是一种运动形式。(宾语从句)

【例 3】 The truth is that the current increases with every decrease of resistance.

电流随每次电阻减少而增加，这是真理。(表语从句)

【例 4】The discovery that electrical currents can be produced by magnetism is extremely important in the field of electricity.

磁能产生电流，这一发现在电学上是极为重要的。(同位语从句)

2. 定语从句

定语从句有直接由关系词引导的定语从句与特殊的定语从句或限制性定语从句和非限制性定语从句的分类。

【例 5】 A scalar quantity is one that/which is completely defined by its magnitude alone.

标量是只计大小的量。(关系词引导的定语从句)

【例 6】 The voltmeter is connected across the part of the circuit for which resistance is yet to be determined.

把伏特计接在需要测量电阻的那部分电路的两端。(“介词＋关系代词”引导的定语从句)

【例 7】 A coil of wire that moves in a magnetic field will have an EMF induced on it.

当线圈在磁场运动时，其内部就会感应出一个电动势。(限制性定语从句)

3. 状语从句

状语从句又可具体分为时间状语从句、原因状语从句、目的状语从句、结果状语从句、条件状语从句、比较状语从句、方式状语从句、让步状语从句、地点状语从句九种。

【例 8】 When electrons move from the negative to the positive end of a conductor, the work is done.

当电子从导体的负极流向正极时，就作了功。(时间状语从句)

【例 9】 Small switches control lamps and radio sets because these do not need a large current.

小开关控制灯与收音机，因这些电器用的电流不大。(原因状语从句)

【例 10】 Batteries should be kept in dry places so that electricity should not leak away.

电池应该放在干燥的地方，以免漏电。(目的状语从句)

【例 11】 The resistance of an inductor is so small that it is negligible.

电感器的电阻小得可以忽略不计。(结果状语从句)

【例 12】 If the voltage is doubled without changing the resistance, the current is increased.

如果电阻不变而电压增加了一倍，那么电流就增加了。(条件状语从句)

【例 13】 Silver conducts electricity better than other metals.

银比其他金属容易导电。(比较状语从句)

【例 14】 The coil carrying currents has a magnetic field, as if it were a magnet.

载流线圈好像磁体一样具有磁场。(方式状语从句)

【例 15】 Though radar uses radio waves, it is somewhat different from radio and television.

虽然雷达应用无线电波，但与无线电和电视略有区别。(让步状语从句)

【例 16】 Where there is an electrical current, there are free electrons.

有电流的地方，就有自由电子。(地点状语从句)

4. 定语从句的翻译

英语中的定语从句，无论是限定性，还是非限定性的，总是放在所修饰的名词后面；而汉语中的定语从句总是放在所修饰的名词前面，但定语太长，又不符合汉语的习惯。下面介绍几种翻译定语从句的译法。

(1) 译成前置定语。

限制性定语从句往往译成前置定语结构，即译成“……的”。但有些非限制性定语从句有时也可做前置处理，尤其是当从句本身较短，或与被修饰词关系较为密切，或因拆译造成译文结构松散时。

【例 17】 In the design of concrete structures, an engineer can specify the type of material that he will use.

在混凝土结构设计中，工程师可以指定他将要使用的材料品种。

(2) 译成简单句。

当英语中定语从句的结构比较简单，且主句又多为“there + be + 主语”句型时，或者主句虽不是这种句型，但从句与其他所修饰的词的关系比较密切，意思上的联系不可分割时，往往把从句作为主体，把主句并进去，译成简单句。

【例 18】 Unlike an LCD screen, which uses power all the time, energy is no longer needed to view the electronic book’s pages once they are typeset.

它和液晶屏不一样，液晶屏时时都离不开电源，而电子书页一经排好，阅读时就再也不需要电源了。

(3) 译成并列句。

非限制性定语从句往往需要拆译成并列句，有时，限制性定语从句因从句本身太长，前置会使句子显得臃肿，故也可采用拆译分列。

【例 19】The tendons are frequently passed through continuous channels formed by metal or plastic ducts, which are positioned securely in the forms before the concrete is cast.

预应力钢筋束穿入用金属管或塑胶管支撑的连续孔道，而金属管或塑胶管在浇筑混凝土之前被固定在模板之中。

(4) 译成状语从句。

英语中有些定语从句有时在内容上还含有明显的时间、条件、原因、让步等状语意思。英译汉时，可将主句与从句分开翻译，把从句译成各种状语从句。

【例 20】 Computers, which have many advantages, cannot carry out creative work and replace man.

虽然计算机有很多优点，但他们不能进行创造性的工作，代替不了人。

# Chapter 13

## Environment Engineering

### Section A Energy and Environment

Production is the basis for the existence and the development of human society. Human needs are constantly growing and in order to satisfy these needs, man **interacts with** and affects the natural environment in a variety of ways, both positive and negative. At the same time, the natural environmental resources of water, soil, plant and animal life constitute the natural capital on which man depends to satisfy his needs.

By the rapid change of the world's energy and environment situation, we can obviously find out, the amount of natural resources is falling in an unacceptable speed, which we can call an energy crisis. Nevertheless, the situation of the earth's environment is also **bogged** down in crisis. And a lot believes that, these two problems somehow have a **delicacy** connection. Probably it's true, for the over usage of natural resources like coal and oil is the **conjunct** cause of both the problems.

Until recently, land and natural resources could be **exploited** without **restraint**, and wastes could be discharged freely into air and water, which nobody owned. Natural resources were considered **inexhaustible** because many of them have the capability for self regeneration is a rather slow and complicated one; if some natural resources are overexploited, the stock will fall rapidly, leading ultimately to the complete destruction of the resource.

The growth of energy demand **in response to** industrialization, **urbanization**, and societal affluence has led to an extremely uneven global distribution of primary energy consumption. The consumption of energy per person in industrial market economies, for example, is more than 80 times greater than in **sub-Saharan Africa**. And about a quarter of the world's population consumes three-quarters of the world's primary energy.

Many other **scenarios** can be generated in-between, some of which assume an improved energy base for the developing world. For instance, if the average energy consumption in the low and middle income economies **trebled** and doubled, respectively, and if consumption in the high income oil exporting and industrial market and non market countries remained the same as today, then the two groups would be consuming about the same amounts of energy. The low and middle income **categories** would need 10.5 TW and the tree 'high' categories would use 9.3 TW totaling 20 TW globally, assuming that primary energy is used at the same levels of efficiency as today.

How practical are any of these scenarios? Energy analysts have conducted many studies of global energy futures to the years 2020-2030. Such studies do not provide forecasts of future energy needs, but they explore how various technical, economic, and environmental factors may **interact with** supply and demand. In general, the lower scenarios require an energy efficiency revolution.

The higher scenarios **aggravate** the environmental pollution problems that we have experienced since the Second World War.

The environmental risks and uncertainties of s high energy future are also disturbing and give rise to several reservations. First, the serious probability of climate change generated by the 'greenhouse effect' of gases emitted to the atmosphere, the most important of which is carbon dioxide produced from the combustion of fossil fuels. Second, urban industrial air pollution is caused by atmospheric from combustion of fossil fuels. Third, **acidification** of the environment is caused by the same reasons. Fourth, the risks of **nuclear reactor** accidents, the problems of waste disposal and dismantling of reactors after their service life is over, and the dangerous of proliferation associated with the use of nuclear energy.

Most of the countries in the world have **made** great **contribution** in solving the energy crisis by many ways including appealing less coal, natural gas and oil use. The world shall not only think about renewable resources, which have ignored the growing scale in demand of energy in the future, but also consider ways to use the energy in higher efficiency, in order to maximize the usage of every single **joule** of power as well.

The **crucial** point about these lower, energy efficient futures is not whether they are perfectly realizable in their proposed time **frames**. Fundamental political and **institutional** shifts are required to **restructure** investment potential in order to move along these lower, more enezrgy-efficient paths.

The World Environment and Development Committee believes that there is no other realistic option open to the world for the 21st century. The ideas behind these lower scenarios are not **fanciful**. Energy efficiency has already shown cost effective results. In many industrial countries, the primary energy required to produce a unit of GDP has fallen by as much as a quarter or even a third over the last 13years, much of it from implementing energy efficiency measures. Properly managed, efficiency measures could allow industrial nations to stabilize their primary energy consumption by the turn of the century. They would also enable developing countries to achieve higher levels of growth with much reduced levels of investment, foreign debt, and environmental damage. But by the early decades of the 21st century they will not alleviate the ultimate need for substantial new energy supplies globally.

In conclusion, energy and environment cannot be solved separated. There is delicacy connection between them; as a result, we should consider both problems while thinking solutions.



## Words and Phrases

interact with 与……相互作用，与……相互影响
bog [ˈbɔg] *vt.&vi.*(使)陷入泥沼
delicacy [ˈdelikəsi] *n.* 微妙，精美
conjunct [kənˈdʒʌŋkt] *adj.* 结合的，联合的
exploit [iksˈplɔit] *vt.* 开采，开发
restraint [risˈtreint] *n.* 约束，遏制
inexhaustible [ˌinigˈzɔːstəbl] *adj.* 用不完的，无穷无尽的
without restraint 无节制的
in response to 为了响应

urbanization [ˌəːbənaiˈzeiʃən] *n.* 都市化
sub-Saharan Africa 撒哈拉沙漠以南的非洲
scenario [siˈnɑːriəu] *n.* 情况，方案
treble [ˈtrebl] *vi.* 使成为三倍，增加两倍
category [ˈkætigəri] *n.* 种类，范畴
aggravate [ˈægrəveit] *vt.* 使恶化，使更严重
acidification [əˌsidifiˈkeiʃən] *n.* 酸化
renewable [riˈnjuəbl] *adj.* 可更新的，可恢复的
nuclear reactor 核反应堆
make contribution 贡献
joule [dʒuːl] *n.* 焦耳(功、能量的单位)
crucial [ˈkruːʃəl] *adj.* 决定性的，关键的
frame [freim] *n.* 框架，计划
institutional [ˌinstiˈtjuːʃənəl] *adj.* 公共机构的，制度上的
restructure [ˌriːˈstrʌktʃə] *vt.* 调整
fanciful [ˈfænsiful] *adj.* 奇异的，空想的

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Nevertheless, the situation of the earth's environment is also ________ down in crisis.
2. Many other ________can be generated in-between, some of which assume an improved energy base for the developing world.
3. The higher scenarios ________ the environmental pollution problems that we have experienced since the Second World War.
4. The ________ point about these lower, energy efficient futures is not whether they are perfectly realizable in their proposed time frames.
5. The ideas behind these lower scenarios are not ________.

Ⅱ. Translate the following passages from English into Chinese.

The economic implications of high energy future are disturbing. A recent World Bank Study indicates that for the period 1980-1995, a 4.1 percent annual growth in energy consumption would require an average annual investment of some $130 billion in developing countries alone. About half of this would have to come from foreign exchange and the rest from internal spending on energy in developing countries.

This raise the desirability of a lower energy future, where GDP growth is not constrained but where investment effort is switched away from building more primary supply sources and put onto the development and supply of highly efficient fuel-saving end use equipment. In this way, the energy services needed by society could be supplied at much reduced levels of primary energy production. By using the most energy efficient technologies and processes now available in all sectors of the economy, annual global per capita GDP growth rates of around 3 percent can be achieved. But this path would require huge structural changes to allow market penetration of

efficient technologies, and it seems unlikely to be fully realizable by most governments during the next 40 years.

## Section B Air Pollution

Quantitative discussions of air pollution are hampered by the lack of a clear definition for 'clean air'. Most scientist assume 'air' to be a mixture of the gases such as Nitrogen, Oxygen, Argon, Carbon dioxide, Neon, Helium, Methane, Krypton, Nitrous oxide, Hydrogen, Xenon, Nitrogen dioxide, Ozone. If this is clean air, then any **constituent** of air can be called a pollutant. However, one never finds such 'clean air' in nature. It may thus be more **appropriate to** define air pollutants as those substances which exist in such concentrations as to cause an unwanted effect. These pollutants can be natural or man-made and can be in the form of gases or **particulates**.

Air pollution may arise from acts of nature. There have been many times when people have been forced to seek shelter indoors during a severe **sandstorm**, when the wind-borne ash from **erupting volcanoes encompassed** large portions of the surface of the earth. Early in the 1950's, forest fires in some of the southeastern states blanketed an area of about 300,000 square mile. The smoke from the forest fires was so intense that air flights had to be canceled in many cities.

But acts of nature are often beyond the control of man. Of chief concern is the second and more pressing source of air pollution—the man-made pollutants.

While, air pollution is not a new phenomenon, it is now apparent that it is one of our most rapidly growing environmental problems. What are the factors contributing to this rather **recent trend** toward deterioration of the air environment? There are three major underlying factors which serve to explain this condition.

The first factor is population growth. The upward trends in population growth in the Unites States, since World War Ⅱ, have indeed been **impressive**. More people mean more manufactured goods and services. This, in turn, lends to the second factor.

The second one is **expansion** in industry and technology. The growth of industrial activity, in the same period, has likewise been **remarkable** in terms of expansion of existing plant capacity, and the increase in number of new manufacturing establishments. In addition, there has been the introduction of a great number of new processes, methods and products. The nature of the airborne wastes from some of these new technologies was completely unknown until **adverse effects** on man and his environment suddenly became **manifest**. New industries and processes introduced on a large scale within recent decades. In most cases, the raw materials and by-products waste initially were of unknown **toxicity** and knowledge of the methods and procedures for **abatement** of resulting pollution problems; aged far behind the technology of manufacture. The combination of increasing quantities of atmospheric **emissions**, including material of undefined character, compounded the growth and complexity of atmospheric pollution.

The third one is social changes. Two important social changes occurred during this same period, and served to **accelerate** the trend of **burgeoning** air pollution:

1. **Urbanization**. The **unrelenting** movement of people from rural sections into urban centers

has led to the rapid evolution of cities into large metropolitan complexes. The result of this development is an ever increasing density of population and of industrial and commercial activity. Thus, the producers of airborne pollutants now, more than ever before, reside in close proximity to the potential receptors.

2. The other social factor which has indirectly contributed to the **intensification** of air pollution over relatively recent years has been raising standard of living which has prevailed during this period. Few families today are without a car, television set, refrigeration, automatic washing machines, etc. The vast majority of these conveniences require electric power.

Modern society produces greater per capita solid refuse than ever before. Greater use of paper, plastic and similar materials for single service containers, and for packaging food and numerous domestic and commercial products of everyday life is placing enormous demands on solid waste disposal facilities. **Open burning** and incinerators of all types and sizes are emitting air-contaminating combustion products of increasing quantities and chemical complexity.

Some of these pollutants, such as automobile gases, are discharged into the air at street level. Others, such as smoke from chimneys of apartment houses or power plants where electricity is generated, enter the atmosphere at higher levels.

The amount of pollution in the cities is affected by atmospheric conditions. Some conditions reduce the pollution and others increase it. If winds are strong enough, they blow pollutants up and away, and rain and snow wash the air. But these natural forces can be slow and also infrequent. Pollution is also lessened by action of currents in the air. Because the surface of the earth is normally warmer than the air above the surface, air currents are set up that rise into the higher atmosphere, carrying the pollutants with them. In this way the amount of pollution on the surface where people live is reduced. But sometimes, due to natural causes, the air above the earth's surface is warmer than the air at the surface. When this happens, the warm air remains in a layer above the cold air at the surface, and stops the normal flow of rising warm air. This is known as a temperature inversion. The air pollution and smog-forming substances become trapped between the two layers and hang over the city, often with serious effects on people's comfort, health and even life.

The combined impact of population growth, expansion in industry and technology and social changes operating in our contemporary society can be regarded as the compounding factors which have resulted in serious degradation of the urban air environment with relatively recent years. In certain **metropolitan** areas, this trend has already reached alarming proportions. In those areas, the rate of pollution very frequently exceeds the capacity of the atmosphere to purify itself by natural processes of dilution and dispersion. During these periods, severe air pollution occurs and is clearly manifested by eye **irritation**, reduced visibility and other adverse effects.

## Words and Phrases

constituent[kən'stitjuənt] *n.* 成分，构成部分，要素
appropriate to 将(某物)分配给……
particulate [pə'tikjulit] *n.* 微粒；*adj.* 微粒的
sandstorm ['sændstɔːm] *n.* 沙暴，沙漠地带的暴风沙
erupt [i'rʌpt] *vi.* 爆发，喷发

volcano [vɔl'keinəu] *n.* 火山
encompass [in'kʌmpəs] *vt.* 围绕，包围
recent trend 近代趋势
impressive [im'presiv] *adj.* 给人印象深刻的，感人的
expansion [iks'pænʃən] *n.* 扩大，膨胀，扩张物，膨胀物
remarkable [ri'mɑːkəbl] *adj.* 异常的，引人注目的，不寻常的
adverse effect 反作用
manifest ['mænifest] *vt.* 清楚表示，显露；*adj.* 明白的，明显的
toxicity [tɔk'sisiti] *n.* 毒性
abatement [ə'beitmənt] *n.* 消除
emission [i'miʃən] *n.* 排放(物)
accelerate [æk'seləreit] *vt.&vi.* (使)加快，(使)增速
burgeoning ['bəːdʒəniŋ] *adj.* 迅速成长的；迅速发展的
urbanization [ˌəːbənai'zeiʃən] *n.* 都市化，文雅化
unrelenting [ˌʌnri'lentiŋ] *adj.* 持续不断的，不松懈的，不屈不挠的
intensification [inˌtensifi'keiʃən] *n.* 激烈化，增强明暗度
open burning 露天焚烧
irritation [ˌiri'teiʃən] *n.* 恼怒，生气；令人恼火的事；疼痛处,疼痛感
metropolitan [ˌmetrə'pɔlitən] *adj.* 大都会的，大城市的

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. It may thus be more ________ define air pollutants as those substances which exist in such concentrations as to cause an unwanted effect.

2. The upward trends in population growth in the Unites States, since World War Ⅱ, have indeed been________.

3. In most cases, the raw materials and by-products waste initially were of unknown ________ and knowledge of the methods and procedures for ________of resulting pollution problems; aged far behind the technology of manufacture.

4. During these periods, severe air pollution occurs and is clearly manifested by eye________, reduced visibility and other adverse effects.

Ⅱ. Translate the following passages from English into Chinese.

In the context of air pollution control, gaseous pollutants include substances that are gases at normal temperature and pressure as well as vapors of substances that are liquid or solid at normal temperature and pressure. Among the gaseous pollutants of great importance in terms of present knowledge are carbon monoxide, hydrocarbons, hydrogen sulfide, nitrogen oxides, ozone and other oxidants and sulfur oxides.

Pollution emissions from industrial processes reflect the ingenuity of modern industrial technology. Thus, nearly every imaginable form of pollutant is emitted in some quantity by some industrial operate.

## Section C Health Effects of Noise

Noise is commonly defined as unwanted sound. In recent years, noise pollution has become increasingly serious with large-scale use of motor vehicles and production equipment. It is vary from the characteristics, quantity, distribution and protection of noise sources, as well as time and place. In the living environment, sound level is about 30 **dB** in the relatively quiet environment at night, it is about 80 dB during the day with the frequent **vehicle**. It can be as high as 90 dB in both sides of the street near the factory or in some areas. Noise level in the work environment is relatively high, such as in the textile, machinery and printing industry, and noise level in some sites is more than 90 dB, sometimes as high as 100～105 dB. Some special sites, such as the site used **pneumatic tool**, testing motors, **vibration** table, noise level even be as high as 120 dB. Noise is higher near the airport **aviation**, it is up to 130 dB.

The impact of noise, it is a normal quiet environment when the noise level is 30～40 dB; When it is more than 50 dB, sleep and rest will be disturbed. Due to lack of rest, **fatigue** can not be eliminated, to a certain extent, the normal **physiological** functions will be affected; the talk will be interfered when noise level are above 70 dB, thus causing upset, lack of concentration and low working efficiency, and even accident may be occurred; a man work or live in more than 90 dB noise environment in long-term, he will seriously affect the hearing and lead to other diseases.

The most immediate and **acute** health **effect** of excessive noise is **impairmen**t of hearing. Hearing damage includes those that are of acute and **chronic**. Exposure to strong noise, **drumming** will be in the ears , as long as it is not long that the ear in strong noise, it will return to after leaving the noisy environment, it is known as the **auditory** adaptation. If it is exposed to strong noise for a long time, hearing loss is more obvious. It takes a few hours, or even a dozen to 20 hours to return to normal after leaving the noisy environment, it is known as auditory fatigue. This is caused by damage to some part of the auditory system.

Sound pressure waves caused by vibration set the ear drum (**tympanic membrane**) in motion. This activates the three bones in the middle ear. Acute damage can occur to the ear drum, but this occurs only with very loud sudden noises. More serious is the chronic damage to the tiny hair cells in the inner ear. Prolonged exposure to noise of a certain frequency pattern can cause either temporary hearing loss, which disappears in a few days, or **permanent** loss. Much of the hearing loss in industry occurs in the middle range of frequencies. Unfortunately, speech frequencies are in the same area, and **speech perception** is thus hindered. Many older people, while still able to hear jet planes and **rumbling** trains quite well, complain that “everyone is whispering”. They have experienced damage to certain hair cells which hinder the reception of sounds of a specific frequency.

Hearing loss occurs with advancing age even without environmental damage. It is difficult, therefore, to develop **epidemiological** date to show the loss due to excessive noise. Research has, however, shown that hearing loss due to noise is real and not imagined.

Another problem with noise is its effect on other bodily functions such as the **cardiovascular**

system. It has been discovered that noise alters the **rhythm** of the heartbeat, makes the blood thicker, dilates **blood vessels** and makes focusing difficult. It is no wonder that excessive noise has been blamed for headaches and irritability. Noise is especially annoying to people who do close work, like watchmakers.

All of the above reactions are those which our ancestral **caveman** also experienced. Noise to him meant danger and his senses and nerves were “up”, and it is questionable how much of our physical ills are due to this.

We also know that man cannot adapt to noise, in the sense that his body functions no longer react a certain way to excessive noise. People do not, therefore, get “used to” noise in the physiological sense.

In addition to the noise problem, it might be appropriate to mention the potential problems of very high or very low frequency sound, out of our usual 20～20,000 **Hz** hearing range. The health effects of these, if any, remain to be studied. Numerous case histories comparing patients in noisy and quiet hospital point to increased **convalescent** time when the hospital was noisy. This can be translated directly to a dollar figure. Recent court cases have been won by workers seeking damages for hearing loss suffered in the job. The Veterans Administration spends many, many millions of dollars every year for care of patients with hearing disorders.

Other costs, such as sleeping pills, lost time in industry, and apartment sound proofing are difficult to quantify. It is even more difficult to measure the effect noise has had on the quality of life. How much is noise to blame for irate husbands and **grumpy** wives, for **grouchy** taxi drivers and surly clerks? Children reared in a noisy neighborhood must be taught to listen. They cannot focus their auditory senses on one sound, such as the voice of a teacher.

The harm of urban environmental noise can be prevented by proper control of noise sources, rational planning of the factory city, reasonable layout of streets and residential areas, an additional effective noise protection facilities and developing noise reduction system of traffic management.

Depending on the purpose, environmental noise standards can be divided into three types: the noise should be controlled at 75～90 dB in order to protect the hearing, the noise should be controlled at 55～70 dB in order to ensure the work and learning, and the noise should be controlled at 35～50 dB in order to ensure the rest and sleep. It is ideal for low value, high-value are not allowed to exceed the limit.

Noise is a real and dangerous form of environmental pollution. Since people cannot adapt to it physiologically, we are perhaps adapting physiologically instead. Noise can keep our senses “on edge” and prevent us from relaxing. Our mental powers must therefore control this insult to our bodies. Since noise, in the context of human evolution, is a very recent development, we have not yet adapted to it, and must thus be living on our **buffer capacity**. One wonders how plentiful this is.

## Words and Phrases

dB *abbr.* decibel, decibels 分贝
vehicle [ˈviːikl] *n.* 交通工具，车辆，传播媒介，手段
pneumatic tool 风动工具，气动工具
vibration [vaiˈbreiʃən] *n.* 振动，偏离平衡位置的一次性往复振动

aviation [ˌeiviˈeiʃən] *n.* 航空，航空学；航空工业
fatigue [fəˈtiːg] *n.* 疲劳，劳累，杂役
physiological [ˌfiziəˈlɔdʒikəl] *adj.* 生理学的，生理的
acute effect 急性效应(作用)
impairment [imˈpɛəmənt] *n.* 损害,损伤
chronic [ˈkrɔnik] *adj.* 长期患病的；慢性的
drumming [ˈdrʌmiŋ] *n.* 连续有节奏的声音
auditory [ˈɔːditəri] *adj.* 听觉的，听觉器官的
tympanic [timˈpænik] *adj.* 鼓皮似的，鼓膜的，鼓室的
membrane [ˈmembrein] *n.* (动物或植物体内的)薄膜，隔膜
permanent [ˈpəːmənənt] *adj.* 永久(性)的，固定的
speech perception 言语感受
rumbling [ˈrʌmbliŋ] *n.* 隆隆声，辘辘声
epidemiological[ˌepiˌdiːmiɔlˈədʒikəl] *adj.* 流行病的
cardiovascular [ˌkɑːdiəuˈvæskjulə] *adj.* 心血管的
rhythm [ˈriðəm] *n.* 节奏，韵律
blood vessel 血管
caveman [ˈkeivmæn] *n.* (史前石器时代的)穴居人，野人
Hz *abbr.* hertz 赫兹
convalescent [ˌkɔnvəˈlesənt] *adj.* 恢复(期)的，康复期的；*n.* 恢复期的病人
grumpy [ˈgrʌmpi] *adj.* 脾气坏的，生气的
grouchy [ˈgrautʃi] *adj.* 脾气不好并常发牢骚的，好抱怨的
buffer [ˈbʌfə] *n.* 起缓冲作用的人(或物)；*vt.* 缓冲，减轻



## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Some special sites, such as the site used pneumatic tool, testing motors, ________ table, noise level even be as high as 120 dB. Noise is higher near the airport ________, it is up to 130 dB.

2. Prolonged exposure to noise of a certain frequency pattern can cause either temporary hearing loss, which disappears in a few days, or________ loss.

3. It has been discovered that noise alters the ________ of the heartbeat, makes the blood thicker, dilates ________ and makes focusing difficult.

4. How much is noise to blame for irate husbands and grumpy wives, for ________ taxi drivers and surly clerks?

Ⅱ. Translate the following passages from English into Chinese.

The difference between the noise scale in dB and actual noise levels must be noted. Doubling the intensity by two identical sources of noise will increase the noise level by approximately 3 dB. In terms of hearing, about a 10 dB increase is necessary to make a sound seem twice as loud to a listener.

If the noise level is too high when compared with a standard or criterion, noise abatement measure must be implemented. Such measures work best if they are aimed at the source of the noise. There are basically four different ways in which noise levels can be controlled or reduced:

(1) Protect the person exposed to the noise.

(2) Intercept the noise by blocking its path.

(3) Increase the distance from the source.

(4) Reduce the sound intensity at the source.

# 参 考 译 文

## 第13章　环 境 工 程

Section A　能源和环境

生产是人类社会存在和发展的基础。人类的需求是不断增加的，为了满足这些需要，人类以各种各样的方式与自然环境相互作用并且影响着，这些影响是积极或消极的。与此同时，人满足他的需要取决于自然环境资源的水、土壤、植物和动物的生命构成的自然资本。

随着世界能源和环境的迅速变化，我们可以明显地发现，大量的自然资源是以不可接受的速度减少，我们可以称之为能源危机。然而，地球环境也陷入了危机形势。很多人认为，这两个问题有某种微妙联系。也许这是真的，过量使用自然资源像煤炭和石油，是和这两个问题有关联的。

直到最近，土地和自然资源毫无节制的使用，废物可以自由排入空气和水，这些不属于任何人。天然资源被认为是取之不尽的，因为大多数是可以进行自我再生，但这个过程是相当缓慢和复杂的。如果一些自然资源过度开发，股市将迅速下跌，最终导致彻底破坏资源。

伴随着工业化、城市化的不断发展以及社会富裕程度的增强而导致的对能源需求量的日益增长，使得全球对初级能源的消耗量的分布变得极不均匀。例如，工业化市场经济中的人均能耗量为非洲撒哈拉沙漠周围地区的 80 倍以上。同时，占世界约 1/4 的人口却消耗了世界初级能源的 3/4。

这其中可能会出现多种不同的情形，其中之一是假定发展中国家对能源利用率的提高。例如，如果低经济收入国家和中等经济收入国家的经济发展水平分别翻两番和翻一番的话，同时如果高经济收入的石油输出国、工业化国家及非工业化市场国家的能耗量保持目前的水平的话，则中低经济收入国家需要耗能 10.5 TW，而三类高经济收入国家需耗能 9.3 TW——全球总能耗为 20 TW 左右。

这些情形的现实性如何呢？能源分析家对 2020—2030 年全球能源未来进行过许多研究。虽然这些研究并未对未来能源的需求量做出预测，但它们对各种技术、经济和环境因素与能源的供给和需求量之间的可能的作用关系进行了探索。一般而言，较低的能耗需要提高能源的利用率，而较高的能耗将加重自二次世界大战以来人们所经历过的环境污染问题。

未来的高能耗所带来的环境危机和不确定性同样很混乱，而且会导致其他问题。其中四个问题最明显。第一，由于向大气排放多种气体，尤其是矿物燃料燃烧过程中产生的二氧化碳，所产生的温室效应极可能改变气候；第二，由于矿物燃料燃烧所产生的大气污染物而导致城市工业空气污染；第三，由于上述同样的原因引起的环境酸化问题；第四，核反应堆事故的危险性，核反应堆使用期结束后废弃物处置及设施的拆除造成的问题，与核能利用有关

的核扩散的危险等。

世界上大多数国家已经通过很多方法在解决能源危机上做出巨大贡献，包括呼吁减少煤、天然气和石油使用。世界不应该仅仅考虑可再生资源，忽略了未来对能源需求的增加，而且还应该考虑如何利用能源的效率更高，以便最大限度地使用每一个焦耳能量。

低能耗、高效率未来的关键点并不是它们是否能在建议的时间框架内得以充分的实现。而是要求在政治上和机构上做出根本性的变革，重新调整投资趋势，以走上低能耗以及更高效率的道路。

世界环境和发展委员会相信，21 世纪的世界没有其他现实的选择。低能耗、高效率的思想并非是异想天开。提高能源利用效率已表明了其成本效益。在许多工业化国家，产生一个单位 GDP 所需的初级能源在过去的 13 年中已经减少 1/4 乃至 1/3，而其中大多数是因为采取了提高能源利用率措施的结果。21 世纪初，工业化国家通过合理的管理及采用提高能源利用率的措施而使其初级能源的消耗量得以基本稳定。它们也同样使发展中国家实现更高增长速率，同时大大降低投资、减少外债、缓解环境危害。但在 21 世纪的最初几十年中，它们不能最终缓解全球范围内对大量新能源的需求量。

总之，能源和环境不能分开来解决。它们之间有着微妙的联系，因此，我们应该考虑这两个问题，同时考虑解决方案。

Section B　空气污染

关于对空气污染的定量研讨，由于缺乏对“洁净空气”的明确定义而有困难。大多数科学家认为“空气”应该是由氮、氧、氩、二氧化碳、氖、氦、甲烷、氪、一氧化二氮、氢、氙、二氧化氮、臭氧等组成的混合气体。如果这种空气就是洁净空气，那么空气中的任何成分都可以称为污染物。然而，大气中永远找不到如此的“洁净空气”。因此将那些足以产生有害影响的有一定浓度的物质定义为空气污染物或许比较恰当。这些污染可能来自自然界或者人类自己。它们可能是气态，或者是颗粒状。

空气污染可能来源于自然行为。当由于火山爆发的风媒灰大部分掩盖了地球表面时，很多时候，在严重的沙尘暴期间人们被迫躲在屋子里。早在 19 世纪 50 年代，森林火灾在一些国家笼罩东南部，面积约 30 $mile^2$($1\ mile^2=2.589\ 99\times10^6\ m^2$)。森林火灾所产生的烟雾十分激烈，许多城市的航班不得不取消。

虽然污染并不是一种新的现象，但现在，它显然是飞速恶化的环境问题之一，在大气环境最近趋近于恶化的过程中起作用的因素是什么呢？主要有下列三大因素，可以说明这个问题。

第一个因素是人口的增长问题。第二次世界大战以来，美国人口增长的趋势，确实令人难以忘怀。人口越多，就意味着制造的商品和提供的劳务也越多，这反过来又导致了第二个因素。

第二个因素是工业和技术的扩展。从现有工厂生产能力的扩大和新的制造加工企业数目的增加来看，同一时期工业活动的增加也同样引人注目。另外，还引进了大量的新工艺、新方法和新产品。由这些新技术的一部分所带来的空中废物，直到在它们对人类及其环境的有害影响突然变得明显滞后，人们对此才有所了解。最近几十年内大规模引进了新产业和新工艺，包括钢铁生产的氧矛切割，石油产品的催化裂解，共聚物的生产和原子能。在大多数情况下，人们最初并不知道其原料和副产品废料所具有的毒性；同时有关怎么缓和所产生污染问题的方法与步骤等方面的知识，也远远落后于制造加工技术。大量增加的空中排放物，包括特性不明的各种物质相互结合，又促使大气污染恶化和复杂化。

第三个因素是社会变化，在同一时期发生了两种重要的社会变化，从而加速了大气污染恶化的趋势。

1. 都市化。人们竭力从农村地区迁到都市中心居住已导致城市飞快地发展成为大都会。而发展结果是人口、工商业活动密度不断增加。这样，空中污染物的制造者比以前更多，而又与可能的接受体很靠近。

2. 近几年来间接促使大气污染强化的另一社会因素，是这段时期中人们生活水平的普遍提高。大部分人口在经济上已经能过上较好的生活，包括高质量的食品、住房、交通工具和种种省力装置。在今天，很少有家庭没有小汽车、电视机、电冰箱、自动洗衣机和干燥机等。这些巨大数量的设备大多需要电能。

在现代社会里，每个人所制造的固体垃圾比以往任何时候都多，更多的使用纸、塑料和类似的材料制作专用容器以及食品和大量生活用品的包装，极其需要固体废物处理设施。各种类型、各种规模的露天燃烧和煅烧炉散发出的污染空气的燃烧产物，其数量与化学复杂性不断上升。

其中的一些污染，如汽车的尾气，在大街上被排放到空气中。而另一些污染，如公寓烟囱或电厂发电时的烟雾，进入更高的大气层中。

大量的城市污染是受大气条件影响的。一些条件下减少污染而其他条件增加污染。如果风力足够强大，可以将污染物吹走，而雨和雪可以净化空气。但是，这些自然力量可能是缓慢的，并不多见。空气中的电流也可以减少污染。

因为地球表面的气温通常比上空空气的气温高，所以地球表面气流会上升到更高的大气中，同时将污染物带走。这样，人类居住的地方大量的污染物会减少。但是有时，由于自然原因，地球表面以上的空气温度比地球表面的空气温度高。在这种情况下，温暖的空气仍然停留在这一层，而冷空气停留在表面，正常流动上升的暖空气停止。这就是所谓的逆温层。空气污染和烟雾形成的表面成为两层之间而悬在城市上空，往往会严重影响人们的舒适、健康甚至生命。

当今社会人口的增长、工业和技术的发展以及社会变化的联合影响，可以看作是近年来导致城市空气环境严重变质的复合因素。在某些大城市，这种趋势已经达到惊人的地步。在那些地区，污染速率经常超过了大气本身具有的扩散稀释等自然净化能力。在这期间发生严重的空气污染，并从对人眼的刺激，大气能见度降低和其他有害影响中清楚地显露出来。



Section C　噪声对健康的影响

噪声通常被定义为不想要的声音。近年来，机动车辆的大量使用和生产设备机械化程度不断提高，致使噪声污染变得越来越严重。其大小随噪声源的特点、数量、分布和防护情况以及时间和地点而异。在居住环境中，夜晚比较安静环境的声级约为 30 dB，到白天车辆频繁来往时约为 80 dB。在工厂附近或街道两旁有些地区可高达 90 dB。某些工作环境中的噪声强度是比较高的，如在纺织、机械和印刷等行业中，有的作业地点噪声级超过 90 dB，有的高达 100～105 dB。有些特殊作业地点，如使用风动工具、试验电动机、操纵振动台等的工作地点甚至可高达 120 dB。机场附近航空噪声更高，可达 130 dB。

噪声的影响。噪声级为 30～40 dB 是比较安静的正常环境；超过 50 dB 就会影响睡眠和休息。由于休息不足，疲劳不能消除，正常生理功能会受到一定的影响；70 dB 以上干扰谈话，造成心烦意乱，精神不集中，影响工作效率，甚至发生事故；长期工作或生活在 90 dB 以上的噪声环境，会严重影响听力和导致其他疾病的发生。

强噪声对健康最直接的急性危害是听力下降，其原因是耳组织的某些部分受到损害。听力损伤有急性和慢性之分。接触较强噪声，会出现耳鸣、听力下降，只要时间不长，一旦离开噪声环境后，很快就能恢复正常，称为听觉适应。如果接触强噪声的时间较长，听力下降比较明显，则离开噪声环境后，就需要几小时，甚至十几到二十几小时的时间，才能恢复正常，称为听觉疲劳。

振荡引起的声压波使中耳(鼓膜)发生运动，这使中耳的三根耳骨活化。急性损害能波及中耳，而这只在骤然出现很响的噪声时才会产生。更严重的损害时对内耳中微小的毛细胞有慢性损害。长久地暴露于一定频率的噪声能导致或是几天即可消失的暂时失聪，或是永久性失聪。工业中中等频率的噪声会使许多人失聪。不幸的是，语言的频率也是中等，因此语言听力常受到阻碍。许多老人，当他们还能听到喷气式飞机的声音及隆隆的火车声时，却抱怨“人们都在耳语”。他们的某些毛细胞受到了损害，妨碍了对特殊(语言)频率声音的接受。

年龄的增长也会引起失聪，因此难以建立表明失聪是由强噪声引起的流行病学数据，但是研究表明，噪声确实可引起失聪，不是人们想象出来的。

噪声的另一个问题是它对人体的其他功能，如心血管系统的影响。已经发现，噪声可以改变心跳的节律，使血液黏稠，血管扩张，并使之难以调节。毫无疑问，强噪声会引起疼痛及烦躁。做精密工作的人们，如钟表制造工对噪声尤其头疼。

我们也认识到，人类不能适应噪声，也就是说人体功能不再能经受强噪声，因此人们在生理官能上不能“习惯于”噪声。

除噪声问题之外，还必须适当的指出在我们通常的 20～20,000 Hz 听觉范围外的超高和超低频率声音的潜在危害问题。它们对健康的危害有待进一步研究。对在喧闹的和安静的医院内患者的比较大量既往事实表明，当医院环境喧闹时，患者的恢复期增长。这可能带来直接的经济影响。近来的法庭案例中，劳动者在工作中遭到失聪的要求赔偿费用，赢得胜诉。美国退役军人管理局每年为医治患听觉疾病的病人耗费许许多多百万美元。

其他费用，如安眠药，工业上损失的时间，以及建造隔音的公寓费用等难以估算。要测定噪声对生活质量的影响更为困难。对丈夫的发怒，妻子的暴躁，出租车司机的愠怒和店员的愤怒，噪声应该负多大的责任？在喧闹的环境中成长起来的孩子，必须教会他们去听，他们不能将听觉集中于一个声音，如老师的声音。

适当控制噪声源，合理规划城市的工厂、街道和居民区的布局，增设有效的噪声防护设施，制订降低噪声的交通管理制度，可以防止城市环境噪声的危害。

根据不同的目的，环境噪声标准可分为三种：为了保护听力，噪声应控制在 75～90 dB；为了保证工作和学习，应控制在 55～70 dB；为了保证休息和睡眠，应控制在 35～50 dB。其中低值是理想的数值，高值是不容许超过的数值。

噪声是一种真正危险的环境污染，既然人们在生理上无法适应它，我们也许在心理上要适应它。噪声使我们感官处于“紧张”状态，没法放松。因此必须用我们的心理能力来控制噪声对人体的伤害。因此人类进化的过程中，噪声是最近才发展起来的，我们还没有适应它，因为必须靠我们的缓冲能力而生活。人们惊奇地发现这种能力有多么巨大。

# Grammar：专业英语的翻译技巧(Ⅸ)——特殊句型的译法(2)

## Translation Skills of English for Professional Purpose Ⅸ—Translation of Special Sentence Pattern(2)

### Ⅰ.否定句的翻译(Negative Sentences)

英语和汉语一样，在表达的形式上有肯定形式和否定形式之分。一般来说，在翻译时应把肯定形式译成肯定形式，否定形式译成否定形式。但有时却不然，就是说英语中的否定形式要译成汉语的肯定形式，而英语的肯定形式反而要译成汉语的否定形式，这样更符合汉语习惯。

英语否定句由否定词构成。英语否定词分两类：一类是 no, not, never, neither, nor, none 等直接表示否定，和汉语的“不”，“没有”，“绝不”，“既不……也不……”相当(否定词 no 和 body, thing, where 构成 nobody, nothing, nowhere 也属于否定词)；另一类是 rarely, seldom, scarcely, hardly, barely, little, few 等表示讲话人观念上的否定，和汉语的“难得”，“几乎不”，“何况”，“不用说”等相当。

英语的否定形式的表示方法很多，主要有：全部否定、部分否定、双重否定、转移否定、意义否定等。在翻译时，要特别注意否定的范围、否定之含义和否定之表达。

1. 全部否定

英语中的全部否定通常是用一些否定词来表达的，如 no, not, none, never, nor 等。有这类否定词的否定句一般仍译为否定句，但否定词的词序有时有所变动，空间怎样变动，视句子的意思而定。

【例 1】Provision of a good or service by a government does not render that good or service a public good, whether the good is public depends on its appropriability.

由政府提供产品或服务并不会使它们变成公用资源：资源是否为公用的取决于其是否具有私用性。

【例 2】 I have answered every single question, but my opponent has answered none.

我已回答了每个问题，但我的对手却一个问题都没回答。

2. 部分否定

英语中的部分否定是由 all, every, each, both, always, often, everything, total, completely 等词与 not 结合而构成的。Not 可在上述词之前，也可在谓语中。无论 not 在什么地方，通常译成“不全是”、“不总是”、“并非”、“未必都”、“不常”等。

【例 3】 All that glitters is not gold.

闪光的未必都是金子。

【例 4】 Both of the answers are not right.

两种答案并非都对。

【例 5】 All institutions have not an officer for each of these areas.

并非所有的高校都有这样一个官员来负责每一个职能的工作。

【例 6】 The economic crisis is a moral wound to the capitalist system, and all the remedies in the world won’t heal it.

经济危机是资本主义的致命伤，世上没有灵丹妙药能治好这种创伤。

【例 7】 All matters are not visible.

并不是所有物质都是可见的。

【例 8】 All these building materials are not good products.

这类建筑材料并不都是优质产品。

3. 双重否定

双重否定通常是由 no (not)等与某些表示否定意义的词连用而构成，表示否定的否定。译成汉语时，可以是肯定形式，也可以保持双重否定的形式，视汉语的习惯而定。

【例 9】 There is no law that has not exceptions.

凡是规律都有例外。

【例 10】 Without scientific experiment and without new techniques, there can be no great increase in labor productivity, and our socialist system will not be able to display its superiority to the full.

不搞科学实验，不采用新技术，就不能大幅度地提高劳动生产率，就不能充分显示我国社会主义制度的优越性。

【例 11】 The common characteristics of these services are that once they are made available, separation of these who have paid from those who haven't paid is impossible, and any number of people can consume the same good at the same time without diminishing the amount of good available for anyone else to consume.

这些服务的共同特点是，一旦提供了这些服务，要区分付钱的和不付钱的是不可能的，任何数量的人都可以同时消费这些资源，而不会减少他人对该资源的消费量。

【例 12】 But unlike common radio waves, nuclear radiation is not harmless to human beings and other living thing.

但核辐射不同于平常的无线电波，它对人类及其他生物有害。

【例 13】 In fact, there is hardly any sphere of life where electricity may not find useful application.

事实上，电力的应用充斥于生活的各个领域。

【例 14】 It is not until the 12 century that the Europeans began to learn how to use the compass on their ships.

直到 12 世纪，欧洲人才学会利用指南针驾船。

【例 15】 There is no material but will deform more or less under the action of force.

在力的作用下，没有一种材料不或多或少地发生变形。

4. 转移否定

英语中表示信念或推测等意义的动词如 expect, think, suppose, believe 等否定式时，如果其后带有 that 引导的宾语从句或动词不定式表示的宾语补语，这种否定并非真正的否定，而是从句中谓语及宾语补语否定的转移。在翻译时，应把这类动词的否定形式译成肯定，而把其后从句中的谓语或宾语补语译成否定。

【例 16】 I don't think that he can operate the new type of computer.

我认为他不会操作这种新型计算机。

【例 17】 I don't think it's right to make such a hasty decision.

我认为这样仓促地做出决定是不恰当的。

【例 18】 But it should be remembered that so great have been geological changes, that nowhere on earth today do we find the crust in its original form.

但是，应当记住，在发现了那么巨大的地质变化以后，在今天的地球上再也找不到原始形态的地壳了。(否定转移到动词)

【例 19】 In general, no new substance forms in a physical change.

一般来说，物理变化不生成新的物质。(原文否定名词，译文否定动词)

5. 意义否定

英语中有些动词、名词、介词、形容词、副词等在形式上是肯定的，但含义是否定的，如“against, failure, too, too…to, instead of, free from, anything but, prevent from, 等等。意义否定是一种有意无形的含蓄的否定，它渗透到英语的各种句型中。在翻译时，常译成汉语的否定形式。

【例 20】The initial element is failure of exclusion: there is no way to prevent people from receiving the service even though they have not paid for it.

第一要素是不具排他性：即使人们不付钱，也无法阻止他们享受这种服务。

【例 21】 The first function, stabilization and growth, involves the combat against unemployment and inflation and provision for increases in the standard of living for the citizenry.

第一种职能，稳定和发展，关系到减少失业，防止通货膨胀，供给物资以提高市民的生活水平。

【例 22】 Quick analysis is a way to avoid the measurement trap because it focuses attention on the important components of a decision rather than the easily quantifiable ones.

快速分析是一种避免测量陷阱的方法，因为它是关注决策的重要组成部分，而不是关注那些容易测量的因素。

【例 23】 The analysis is too complicated for us to complete the computation on time.

分析工作太复杂，难以按时完工。

Ⅱ.强调句的翻译(Emphasized Sentence)

一、强调句型

1. 完整的句型

It + be 的不同时态形式＋被强调的成分＋that (which; who)…

注：

(1) 对于 be，最常见的形式是 is(用于现在的各种时态)和 was(用于过去的各种时态)；还可有 may be, must be, will be, has been 等形式。

(2) 被强调的成分可以有：主语、宾语、状语(副词，介词短语，状语从句，表示目的的动词不定式)以及介词宾语。

(3) 在句型中，that 用于强调任何词所承担的主语、宾语、状语、把介词放在句尾时的介词宾语；which 只能用来强调表示事物的议事、宾语、介词宾语；who 只能用来强调表示人的主语(如果要表示强调人的宾语时，应使用 whom，不过这在科技文中极少见到)。

(4) 当强调介词宾语时，其句型可以有两种形式：It is (was 等) + 被强调的成分 +介词 + which(whom)…; It is (was 等) + 被强调的成分 ＋ who (which; that)… + 介词。

(5) 该句型有否定式：在 be 的时态形式后＋not；该句型有疑问式：把 is, are 等放在 it 之前。

(6) 该句型的判别法：如果把 it, be, that(which, who)这三个词去掉后，留下的东西仍可组成一个完整的句子的话，那么一般来说该句就属于强调句型。

2. 译法

该句型一般译成“正是；是”。有时可译成“就是；只是”。

当强调引出疑问句的疑问词、引导名词从句的连接代词和连接副词时，该句型应译成“到底，究竟”。

【例 1】 It is the losses caused by friction which we must try to overcome.

我们必须力求克服的正是由摩擦引起的各种损耗。(本句强调了宾语)

【例 2】 It is these drawbacks which need to be eliminated and which have led to the search for new methods of construction.

正是因为有这些缺点需要消除，才导致了对施工新方法的研究探求。(本句强调了主语)

【例 3】 It is this kind of steel that the construction worksite needs most urgently.

建筑工地最急需的正是这种钢材。(本句强调了宾语)

【例 4】 It is when an object is heated that the average speed of molecules is increased.

正是当物体受热时，分子的平均速度提高了。(本句强调了状语从句)

【例 5】 It is only when piers for long span bridges is built across wide rivers that cellular cofferdams are often used.

只有当需要在宽阔的河面上构筑大跨度桥的桥墩时，才经常使用格型围堰这种方法。(本句强调了状语从句)

【例 6】 It is the net force on an object that causes acceleration.

正是作用在物体上的净力引起了加速度。(本句强调了主语)

【例 7】 However, it is just this distinction with which the second law of thermodynamics is concerned.

然而，热力学第二定律所涉及的就是这一特性。(本句强调的是介词宾语)本句也可写成：it is just this distinction that (which) the second law of thermodynamics is concerned with. 不过在正式的科技文中，外国人喜欢用“介词+which”的形式。

二、利用某些词加强语气

1. 用助动词 do (does; did)来强调谓语动词

动词本身没有词义。其形式有：




译成：确实，的确；一定，真的。

【例 8】 Mathematical analysis shows that these methods do work, but it is not clear yet under what conditions it is that they may be used.

数学分析表明，这些方法是确实可行的，但是尚不清楚到底在什么条件下才能使用它们。

【例 9】 The moon does have gravity.

月球的确具有引力。

【例 10】 If the positive charges did move in a wire, they would flow from the positive terminal to the negative one.

如果正电荷真的能在导线中运动的话，它们就会从正端流向负端。(本句属于条件式虚拟语气句型)

2. 用形容词 very 来强调名词

其形式为：

The (this; that; no; 物主代词)+名词

译成：就；正；最；那个。

【例 11】 The alternating current is the very current that makes radio and television possible.

交流电就是使无线电和电视成为可能的那种电流。

【例 12】 The current starts to flow at the very moment we close the circuit.

就在我们闭合电路的那一瞬间，电流就开始流动。

【例 13】 In this way, when the instrument is inserted, it does not change the very thing we wish to measure.

这样，当把仪表接入电路后，它不会改变我们想要测量的那个量。

3. 用某些副词来加强语气

常见的这类副词有：only, merely, simply, never, right, even, alone, 等等。

【例 14】 To get right away from the earth, an object will have to fly into space at a speed of seven miles per second.

为了正好能离开地球，物体必须以 7mile/s 的速度飞入太空。

4. 采用由 no matter…(… ever )引导的状语从句来加强语气

【例 15】 No matter how (however) small a particle may be , it has weight.

不论微粒有多小，它总是具有重量的。(在从句中采用了“表语＋连系动词”的句型)

三、采用倒装句型

【例 16】 So small are atoms that we cannot see them with our naked eyes.

原子实在太小了，以至于我们用肉眼是看不见它们的。

【例 17】 This process we call automation.

这一过程我们称之为自动化。(把宾语提到了主语前)

【例 18】 Electricity makes possible a great many things.

电使得许许多多的东西成为可能了。

# Chapter 14

# Heating and Refrigeration

## Section A Introduction of Heating and Refrigeration

The energy used to heat and cool many buildings often comes from a central location in the facility. The energy input may be any combination of electricity, oil, gas, solar, etc. This energy is typically converted into hot or chilled water or steam that is distributed throughout the facility for heating and cooling.

### Heating

**Heating** is concerned with raising the temperature of the thermal environment. Making fire was among man's earliest achievements, and doubtless wood formed the earliest of fuels, first in caves, as remains of Stone Age hearths show, and later in mud and turf enclosures. Heating by a fire outside the space to be heated, now described as central heating, appears. All heating systems are composed by heat source, heat supply and **radiator**. The steam or hot water is the working medium of the heating system that transfers the heat produced by the boiler to the areas where it will be used.

A **boiler** is the most common device used to add heat to the working medium, which is then distributed throughout the **facility**. Although steam is an acceptable medium for transferring heat between buildings or within a building, low-temperature hot water provides the most common and more uniform means of **perimeter** and general space heating. The working medium may be either water or steam, which can be further be classified by its temperature and pressure range. The term hot-water boiler applies to fuel-fired units that heat water for heating systems. Water heaters differ in that they usually do not have enough space in the top section for use as a steam boiler, but in many respects a water heating boiler is the same as a steam heating boiler of the same type of construction. Many steam heating boilers may serve as water heaters if properly arranged, fitted, and installed. Steam and hot water boilers use gas, oil, coal, electricity, and sometimes, waste material for fuel.

Steam as a medium for heating in radiators and the like is a thing of the past. Steam is, however, often used for the heating of industrial buildings where steam raising plant occurs for process or other purpose. It is also used as a primary **conveyor** of heat to **calorifiers** such as in hospital, where again steam-boiler plant may be required for sundry duties such as in kitchens, laundry and for **sterilizing.** The utilization of steam for heating involves the process of condensation, in which the **latent heat** is removed by the heating-emitting surfaces of the heating system and reverting water at the same temperature.

Comparison with steam: Hot water in a closed system under pressure may be run at any temperature up to its design maximum. Where serving space-heating apparatus, the temperature of the water can be varied according to the weather, so saving on mains heat losses and by better control generally. Variability of temperature is not possible with steam, which must be either on or off and any attempt at **throttling** is liable to cause **water logging** at the remote ends.

Distribution mains: Current practice still refers to a choice between such alternative as single, twin, triple or quadruple pipe systems. The single pipeline, apart from a rare ring main layout, it used for steam as primary fluid over such vast networks as to make condensate return lines prohibitive in first cost and **maintenance** expenditures and where is becomes more economical to run treated water to waste. A twin pipe system is the most common and widely used form of distribution; it comprises a flow and a separate line. Nowadays all types of hot water distribution systems are based upon the two-pipe layout which offers optimum design and economical advantages, thus greatly facilitating most aspects of operation. Triple pipeline systems found limited use for high pressure hot water in Western Europe around the mid-sixties; since the lower water temperatures and pressures became prevalent and increased use was made of efficient direct-in-the ground mains, the third pipe whose duty was to act as conveyor of primary heating water for domestic use during off-heat periods, went out of fashion. A four pipe system intended to cater for separated primary heating and domestic service water networks with central calorifiers installed remote from users, possibly in a boiler house, is now in a state of virtual **obsolescence.**

Heat is transported from the heat production plant to the heat demand centre, which may be some distance away, in the heat **transmission** pipeline. The cost of hot water heat distribution, which includes as well as control systems in the local heat network, depends on a number of factors, including: the heat demand density, the supply and return temperature, the characteristics of the terrain and local **infrastructure**, and whether the development is new or involves **retrofitting**.

## Refrigeration

**Refrigeration** was used by ancient civilization when it was naturally available. The Roman rulers had slaves transport ice and snow from the high mountains to be used to preserve foods and to provide cool beverage in hot weather. Such natural sources of refrigeration were, of course, extremely limited in terms of location, temperature, and scope. Means of producing refrigeration with machinery, called mechanical refrigeration, began to be developed in the 1850s. Today the refrigeration industry is a vast and essential part of any technological society, with yearly sales of equipment amounting to billions of dollars in the United States alone.

It is convenient to classify the application of refrigeration into the following categories: **domestic**, commercial, industrial, and air conditioning. Sometimes transportation is listed as a separate category. Domestic refrigeration is used for food preparation and preservation, ice making, and cooling beverages in the household. Commercial refrigeration is used in retail stores, restaurants, and institutions, for purposes the same as those in the household. Industrial refrigeration in the food industry is needed in processing, preparation, and large-scale preservation. This includes use in food chilling and freezing plants, cold storage warehouses, **breweries**, and dairies, to name a few. Hundreds of other industries use refrigeration; among them are ices making plants, oil

refineries, **pharmaceutical**s. Of course ice skating rinks need refrigeration.

Refrigeration is also widely used in both comfort air conditionings for people and in industrial air conditioning. Industrial air conditioning is used to create the air temperatures, humidity, and cleanliness required for manufacturing processes.

Refrigeration, commonly spoken of as cooling process is more correctly defined as the removal of heat from a substance to bring it to or keep it at a desirable low temperature, below the temperature of the surroundings. The most widespread method of producing mechanical refrigeration is called the vapor compression system. In this system a **volatile** liquid refrigerant is evaporated in an evaporator; this process results in a removal of heat (cooling) from the substance to be cooled. A compressor and condenser are required to maintain the evaporation process and to recover the refrigerant for reuse. Other widely used method is called the absorption refrigeration system. In this process a refrigerant is evaporated (as with the vapor compression system), but the evaporation is maintained by absorbing the refrigerant in another fluid. Other refrigeration methods are **thermoelectric**, steam jet, and air cycle refrigeration. These systems are used only in special applications and their functioning will not be explained here.

The main equipment components of the vapor compression refrigeration system are the familiar **evaporator**, **compressor**, and **condenser**. The equipment may be separate or of the unitary (also called self-contained) type. Unitary equipment is assembled in the factory. The household refrigerator is a common example of unitary equipment. Obvious advantages of unitary equipment are that is more compact and less expensive to manufacture if made in large quantities.

There is a variety of commercial refrigeration equipment; each has a specific function. Reach-in **cabinets**, walk-in coolers, and display cases are widely used in the food service business. Automatic ice makers, drinking water coolers, and refrigerated vending machines are also commonly encountered equipment.

Air conditioning includes heating, cooling, humidifying, and cleaning (filtering) of air in internal environments. Occasionally it will be necessary to mention some aspects of air conditioning when we deal with the interface between the two subjects. A study of the fundamentals and equipment involved in air conditioning is nevertheless of great value even for those primarily interested in refrigeration.



## Words and Phrases

heating [ˈhiːtiŋ] *n.* 供热
radiator [ˈreidieitə] *n.* 散热器
boiler [ˈbɔilə] *n.* 锅炉，烧水器，水壶
facility [fəˈsiliti] *n.* 设施
perimeter [pəˈrimitə] *n.* 周边
conveyor [kənˈveiə] *n.* 输送、传递
calorifier [kəˈlɔriˌfaiə] *n.* 加热器，供暖机，热风机
sterilize [ˈsterilaiz] *vt.* 把……消毒
latent heat 潜热
throttle [ˈθrɔtl] *vt.&n.*节流，节流阀

water logging 积水，浸透水
maintenance [ˈmeintinəns] *n.* 维修，保养
obsolescence [ˌɔbsəˈlesəns] *n.* 逐渐过时
transmission [trænzˈmiʃən] *n.* 传送，传播
infrastructure [ˈinfrəˌstrʌktʃə] *n.* 基础设施；基础结构
retrofit [ˈretrəˌfit] *n.* 式样翻新，花样翻新
refrigeration [riˌfridʒəˈreiʃən] *n.* 制冷
domestic [dəˈmestik] *adj.* 家庭的，家用的
brewery [ˈbruəri] *n.* 酿酒厂
pharmaceutical [ˌfɑːməˈsjuːtikəl] *n.* 制药厂
volatile [ˈvɔlətail] *adj.* 挥发性的；易变的，反复无常的
thermoelectric [ˌθəːməuiˈlektrik] *adj.* 热电的
evaporator [iˈvæpəreitə] *n.* 蒸发器
compressor [kəmˈpresə] *n.* 压缩机
condenser [kənˈdensə] *n.* 冷凝器
cabinet [ˈkæbinit] *n.* 橱、柜

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. A ________ is the most common device used to add heat to the working medium, which is then distributed throughout the facility.

2. ________ was used by ancient civilization when it was naturally available.

3. Other refrigeration methods are ________, steam jet, and air cycle refrigeration.

4. The main equipment components of the vapor compression refrigeration system are the familiar ________, ________, and ________.

Ⅱ. Translate the following passages from English into Chinese.

You can use any kind of fuel to warm the water that circulates through the underfloor heating pipe. The most popular choices are oil, gas and solid fuel in the form of a conventional boiler. The best choice is a condensing boiler because these are at their most efficient while working at the lower temperature required by the underfloor heating.

The common practice, more easily adaptable for most conurbation planning and to the widest area spreads, features the “tree branch” network layout, possibly comprising multiple sets of flow and return branches from generation source, with each pair of mains providing for its associated zone with a sub-district.

## Section B Radiant Heating on the Ground

**Radiant heating** on the ground is that warm water is circulated through a series of heating pipes, generally laid in the floor at the time of building. These pipes form a continuous loop

between two central manifolds. Each room has its own circuit of pipes and can be controlled putting the heat exactly where you want it. Radiant heating on the ground has many benefits including **aesthetics** there are no radiators taking up wall space. This allows greater freedom to decorate and furnish the rooms **as you please**. Radiant heating on the ground can also be up to 25% cheaper to operate than a traditional radiator system when a high efficiency condensing boiler. This level of saving can easily be maintained and may even be exceeded.

Modern man demands high levels of **thermal** comfort in artificial environments. Linked to this international pressure grows to reduce demand on the earth's energy reserves. Modern technology has made great strides forward in developing new **innovative** heat sources but probably the greatest advance in combined thermal comfort and energy conservation is the modern wet floor heating system. The advent of high quality plastics pipes has made possible the utilization of how temperature water in floor heating system perfectly **compatible** with the new heat source technology. Fully developed for all types of floor construction, U.F.H. combines all type of heat, **conduction**, radiation and **convection**, matching the ideal **temperature gradient** throughout an entire building. The safe, invisible, space saving, vandal and tamper proof system is both responsive and energy conscious offering passive **self regulation**.

Thermal comfort can be defined as the state of mind where satisfaction is felt with the thermal environment. Research shows that people feel most comfortable when their feet are a little warmer than their heads. Independent tests reveal that the most acceptable indoor climate is one in which the floor temperature ranges between 19~29℃ and the air temperature at heat level ranges between 20~24℃.

However, since individuality is **integral** to all human activity it is not possible to specify one set of environmental conditions which will meet all cases. The best results we are likely to achieve depend on a 5% dissatisfaction factor. There is no temperature that will please everyone, but we can aim to establish a **comfort zone** that will satisfy the highest possible percentage of those using area.

With radiator or convector heating systems **vertical** temperature gradient is produced; colder at foot level than at the head. A modern indoor climate surely demands a heating system which will match the required conditions for human thermal comfort with the principle heating effect being evenly distributed at ground level and not above head level. We have seen that warm feet create good sensations, so let us examine the effect upon the indoor climate if we warm the whole floor to just the right temperature.

We have touched on improvements in building standards but no amount of **insulation** can change the laws of physics—heat still rises. Efficient insulation will, however, serve to trap heat above head level in an area where it can make no contribution to human comfort. Solving this problem involves a close study of the three types of heat available to us. Radiant heat provides the most pleasure sensation of comfort. It contributes to the **exhilaration** of a walk in the spring sunshine even though the ambient air temperature may be only a few degrees above **freezing**. We humans also respond well to conducted heat-the-cat-like pleasure that comes from the warmth of a hot water bottle or just **cuddling up** to another person. Lastly, there is convected heat caused by the effects of the radiation and conduction warming the air and causing it to rise. By using all three types of heat in association we can achieve very high levels of thermal comfort. The normal

criterion for heating design is to achieve a specified air temperature against the given heat loss of the building at a specified outside **ambient** temperature. When designing a floor heating system, however, low air temperature may be acceptable because of the higher level of overall radiation and the added benefit of conduction from warm, friendly floors.

In modern, well insulated building the temperature of the floor surface need be only just above air temperature in order to achieve the required comfort factor. These low temperature differentials result in gentle, low velocity convection throughout the entire building. Low velocity convection reduces the amount of dust in the air in comparison with other types of heating. There are **inaccessible** areas behind radiators or convectors where dust or dirt can collect. It is also cost efficient to operate. Eliminating high velocity convection means there will be no stack of high temperature air above level.

A heated floor is a radiant plane: subjects standing on it will therefore receive the benefit of all round radiation.

A high level of radiant comfort means that air temperature can actually be slightly lower with a floor heating system than those usually required for other methods of heating. Radiation, conduction and convection combine to create the ideal thermal environment for health and comfort.

To warm heat from the feet of Health, Chinese medicine called “the second leg for the human heart”, “Point-intensive areas.” So to warm the body can promote blood circulation, and enhance **endocrine**, played the role of human disease to health, can play in winter heating, the role of summer **moisture**, the proper use of water floor radiant heating system is essential, the use of good green, environmental protection , energy, health, Habitat heating the best choice. To the benefits of Radiant Heating on the Ground are as follows:

(1) Heat transfer and thermal comfort means different: to rely on ground-based low-temperature thermal radiation;

(2) Ideal vertical temperature distribution: the vertical direction, on the lower high;

(3) Reduce air and indoor **dust** vertical convection;

(4) Uniform temperature field level: the level of the same room, the temperature is basically the same;

(5) Reduce dry: the same amount of moisture, air temperature than traditional low-mining;

(6) Stealth, noise-free heating;

(7) Household, the **sub-control** rooms, an ideal energy-saving ;

(8) To apply a wide range of system.

## Words and Phrases

radiant heating 辐射供暖
as you please 随你的意思，随你喜欢
aesthetics [iːs'θetiks] *n.* 美学，美术理论，审美学，美的哲学
thermal ['θəːməl] *adj.* 热的，热量的，由热造成的
innovative['inəuveitiv] *adj.* 新发明的，新引进的
compatible [kəm'pætəbl] *adj.* 可以并存的，相容的，协调的
conduction [kən'dʌkʃən] *n.* (热、电等的)传导，导热，导电

convection [kən'vekʃən] *n.* 传送，对流
temperature gradient 温度梯度
self regulation 自动调节，自动平衡
integral ['intigrəl] *adj.* 构成整体所必需的
comfort zone 适宜室温(范围）
vertical ['vəːtikəl] *adj.* 垂直的，竖的
insulation [ˌinsju'leiʃən] *n.* 隔绝，绝缘，隔音，绝缘、隔热或隔音等的材料
exhilaration [igˌzilə'reiʃən] *n.* 令人高兴，愉快
freezing ['friːziŋ] *adj.* 严寒的
cuddle up 蜷缩着睡
ambient ['æmbiənt] *adj.* 周围的，包围着的
inaccessible [ˌinæk'sesəbl] *adj.* 达不到的，不可及的
endocrine ['endəukrain] *n.* 内分泌；内分泌腺，激素
moisture ['mɔistʃə] *n.* 水分，水汽，潮气；*vt.* 使防潮
dust [dʌst] *n.* 灰尘，尘土，尘埃
sub-control 辅助控制器

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. ________ on the ground is that warm water is circulated through a series of heating pipes, generally laid in the floor at the time of building.

2. Modern man demands high levels of ________ comfort in artificial environments.

3. We have touched on improvements in building standards but no amount of ________ can change the laws of physics—heat still rises.

4. It contributes to the ________ of a walk in the spring sunshine even though the ambient air temperature may be only a few degrees above ________.

Ⅱ. Translate the following passages from English into Chinese.

The installation of a floor heating system can also be used to cool the residence. There are several issues related to floor cooling:

(1) Cooling power is limited due to small temperature difference between supply water and room air.

(2) Floor surface temperature should not be less than 19℃.

(3) The dew point of the indoor air has to be kept below the supply water temperature.

When designed well, hydronic radiant heating and cooling systems operate with temperature close to design room air temperatures. When mated with a ground-source heat pump, these systems provide excellent energy efficiency. High heating supply water temperature and low cooling supply water temperature reduce the energy efficiency.

## Section C Solar Energy in Buildings

The energy that the earth receives from the sun is called solar energy. The sun has provided, either directly or indirectly, almost all other sources of energy for the earth since its beginning. As we all know, solar energy is enormous. Each day the sun deposits an average of 1400 **Btu** per square foot of area to the United States, therefore, an area the size of a 1000 square foot home receives **approximately** 511 million Btu per year. However, solar energy can vary from season to season, from 2000 Btu to as low as 500 Btu per square foot per day during a period from June to December. Factors such as cloud cover and **geographical** location affect the total amount of solar energy received. The solar energy is **inexhaustible**, clean and the renewable energy will be future primary energy. How to use the solar energy already was the **hot spot** which various countries scientific and technical worker studied. The development and utilization of solar energy when the first application in the construction, such as the use of solar energy heating, hot water supply, solar cookers, etc.

As known to all, the availability and cost of energy has become **dominant** factors in society today. Obviously, solving the “energy crisis” makes good sense. Many schemes have been proposed for conserving present energy resources and for developing new ones. It is always possible to use less energy in any process. Therefore, energy engineer is created and developed. The first goal of energy engineer is to determine the methods by which energy utilization is reduced but the output remains the same or even increases. The second goal is to determine which methods of using less energy are cost-effective.

Meanwhile, looking for ideal energy sources is also very important to solve energy crisis. The **recipe** for an ideal energy source calls for one that is unlimited in supply, widely available, and inexpensive; it should not add to the earth’s total heat burden or produce chemical air and water pollutants. Solar energy fulfills all of these criteria. Solar energy does not add excess heat to that which must be **radiated from** the earth. On a global basis, utilization of only a small fraction of solar energy reaching the earth could provide for all energy needs.

Solar energy is the most popular of the many **alternate** energy sources being discussed today. Volumes have been written and much said about solar energy. However, many people don’t understand its possibilities and limitations.

Each year approximately 20 percent of the nations energy use is for heating and cooling homes. Solar energy is an alternative that can reduce our dependence on scarce **fossil** fuels with their ever-increasing price.

The use of solar energy in **construction** application except heating, hot water supply substandard, but also has the solar energy refrigeration. Solar energy is unlimited in supply, but its **exploitation** and utilization are limited owing to the limitation of technology and conditions. Solar energy utilization needs an enormous amount of land, and there are economic and environmental problems related to the use of even a fraction of this amount of land for solar energy collection. First, this energy from the sun is **diffuse**, i.e., it is spread out very thinly. It must therefore be

collected by some means because only a small amount of it arrives in one place. Second, the energy received is **intermittent** because the sun shines only during the day and it is often obscured by clouds. Thus, the energy received must be stored until it is needed.

Solar thermal system can have energy storage, or operate without any storage. The storage is most useful when solar radiation availability differs in time from the heat demand. However, many systems can operate without **thermal storage**. In solar cooling systems, for instance, the availability of higher levels of solar radiation occurs usually at the same time when the cooling loads higher. Thus, the system may operate with a good efficiency without thermal storage. The same may happen in solar **cogeneration** systems, or in systems that provide an amount of useful energy which is much lower than the total load. The use of storage also leads to thermal losses. The combination of these effects is, in principle, positive, and solar fraction may be higher than without storage. In order to decide on the advantage of using thermal storage, both possibilities should be evaluated (storage and no storage). An ideal thermal storage would be able to receive heat and not increase its temperature.

Solar energy can be **transformed** either to electricity or to heat allowing, in theory, any refrigeration technology to be driven by it. Still, several constraints concerning both the quality and the quantity of solar energy limit the potential of solar driven or even **solar assisted refrigeration** technologies. Keeping in mind the characteristics of solar electricity and thermo-mechanical systems, and also for reasons of brevity, they will be discussed only to a limited extend.

The electrically driven systems are characterized by the limited useful power that can be achieved by solar means, and also by their fairly high initial cost. At the present time, solar refrigerant have mainly three kinds. The first is the solar **sorption** systems, and the second is solar adsorption refrigeration system, and then finally is the ejector refrigeration system.

In a word, there is still s high research demand for the utilization of solar energy in air conditioning systems, and research mainly focused on solar collectors and, more **intensely** on the sorption cooling technologies. Solar assisted refrigeration appears to be a promising **alternative** to the conventional electrical driven air conditioning units also from an environmental point of view, since it results in decreased $CO_2$ emissions and, in the case of the prevailing solar cooling technologies, in the **elimination** of $CFC_S$ and $HCFC_S$. The latter is expected to influence the developments in the air conditioning **sector** significantly.

## Words and Phrases

Btu *abbr*. British Thermal Unit 英国热量单位
approximately [əprɔksi'mətli] *adv*. 近似地，大约
geographical [dʒiə'græfikəl] *adj*. 地理学的，地理的
inexhaustible [ˌinig'zɔːstəbl] *adj*. 无穷无尽的，用不完的
hot spot 热点
dominant ['dɔminənt] *adj*. 占优势的，支配的
recipe ['resipi] *n*. 烹饪法，食谱，方法，秘诀，诀窍
radiate from 自……发出
alternate ['ɔːltəːneit] *adj*. 轮流的，交替的，代替的；*vt.&vi.* (使)交替，(使)轮换

fossil ['fɔsl] *n.* 化石，老顽固，食古不化的人
construction [kən'strʌkʃən] *n.* 建造，建设；建筑业；建造物，建筑物
exploitation [ˌeksplɔi'teiʃən] *n.* 开发，开采，剥削
diffuse [di'fju:z] *adj.* 四散的，冗长的，累赘的；*vt. & vi.* (使)扩散，(使)弥漫
intermittent [ˌintə'mitənt] *adj.* 间歇的；断断续续的
thermal storage 蓄热器
cogeneration [ˌkəudʒenə'reiʃən] *n.* 同时发热发电
transform [træns'fɔ:m] *vt.&vi.* 改变
solar assisted refrigeration 太阳辅助制冷
sorption ['sɔ:pʃən] *n.* 吸附作用
intensely [in'tensli] *adv.* 激烈地，热情地
alternative [ɔ:l'tə:nətiv] *adj.* 选择性的；*n.* 二者择一，可供选择的事物
elimination [iˌlimi'neiʃən] *n.* 排除，除去，消除，消灭
sector ['sektə] *n.* 部门，部分

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Each day the sun deposits an average of 1400 ________ per square foot of area to the United States, therefore, an area the size of a 1000 square foot home receives ________ 511 million Btu per year.

2. The solar energy is ________, clean and the renewable energy will be future primary energy.

3. Still, several constraints concerning both the quality and the quantity of solar energy limit the potential of solar driven or even ________ technologies.

4. The first is the solar ________ systems, and the second is solar adsorption refrigeration system, and then finally is the ejector refrigeration system.

Ⅱ. Translate the following passages from English into Chinese.

Sorption systems are referring either to open or closed cycles. Open cycles are mainly desiccant systems, while closed cycles are adsorption or absorption systems. In desiccant systems, sorbents are used for the dehumidification of the incoming air, which in that sense is not a refrigeration process, though it is certainly part of air conditioning.

This renewable energy can be used in vapor absorption refrigeration system (VARS) and ejector refrigeration system (ERS). ERS is more advantageous compared to VARS due to high initial cost of VARS. Also ERS can satisfactorily work to realize refrigeration effect while VARS fails to operate at low generator temperature.

# 参 考 译 文

## 第 14 章　供热与制冷概论

### Section A　供热和制冷工程

加热和冷却许多建筑的能量经常来源于一个中央位置的设施。能量输入也许是电、石油、燃气、太阳能等的组合。这些能量典型的被转换成热水或者冷水或蒸汽，通过设备被分配用来供热或制冷。

**供热**

供热被定义为提高室内环境温度。取火是人类最早的成就，毫无疑问最早的燃料是木材，从旧石器时代遗留的壁炉来看，首先是在洞穴里，后来在泥土和草围栏。供热通过室外来加热，现在称之为集中供热，出现了。所有的供热系统由热源、热输送和散热器组成。锅炉产生的蒸汽或者热水是供热系统的工作介质，将热量传递到需要的地方。

锅炉是用来加热供热介质最普通的设备，然后通过一些设备来分配。虽然蒸汽是一种可接收的介质，用来在建筑之间或者建筑之内传热，但是低温热水为周边和一般地方供暖提供了最常用的和更加统一的方式。工作介质可以是热水或者蒸汽，可以用它的温度和压力范围来定义。热水锅炉通过燃烧燃料为供热系统加热水。热水器不同，它们通常没有足够的上方空间区段用作蒸汽锅炉，但在许多方面，在同一类型的建筑中，热水锅炉和蒸汽供热锅炉是一样的。如果适当的安排、安装，许多蒸汽供暖锅炉可作为热水器。蒸汽和热水锅炉可以使用天然气、石油、煤炭、电力、有时还可使用废料为燃料。

散热器等设备用蒸汽作为加热介质已经是过去的事情，但现在很多工业建筑仍然用蒸汽来加热，例如用蒸汽起重设备等。蒸汽也用作热发生器的初级转换器，例如在医院的厨房、洗衣间和消毒间也要用到蒸汽锅炉设备。利用蒸汽加热的过程中涉及凝结，其中潜热是通过供热系统的表面散发的，将水恢复到相同温度下。

与蒸汽比较：封闭系统中处于压力下的热水可以再设计的最大温度值以下的任何温度下运行。用于供暖设施的场合，水的温度可以根据天气改变，所以能减少管道的热量损失，但一般要通过好的控制。而对于蒸汽来讲，温度不可能随时改变，只能是打开或者关闭。任何想减少流量的尝试都有可能导致在较远的端点积水。

供热干管：目前的做法仍然在可供采用的方案中，比如单管、双管、三管及四管系统。除了较少采用的环状干管布局外，单管系统用于把水蒸气当作基本流体分送到分散的管网中，以至于冷凝回水管线的初期投资和维修开支都非常高，把处理过的水废弃掉反而显得更为经济的场合。双管系统是最普遍和广泛使用的供热形式，它包括一条供水管和一条单独的回水管。现在，所有形式的热水供热系统均以双管布局为基础，它具有最佳设计和经济优越性，因此大大简化了很多方面的操作。20 世纪 60 年代中期，在西欧三管系统极少用于高压热水，这是因为当时普遍采用较低的水温和压力，以及越来越多的采用干管直埋方式，而第三根管子的任务是在非采暖期用来输送家庭用热水，这种做法也不再流行。四管式供热系统旨在适应单独的分别设置的主供热系统和家庭用热水管网，集中式换热器安装远离用户，譬如可能在锅炉房内，现在将逐渐过时。

热通过输送管道从热厂输送到用热中心，中心可能在一定的距离之外。热水供热分配网的成本，包括水泵以及局部热网的控制系统，取决于一系列因素，包括热水密度、供水和回水温度、地形特征、当地基础设施以及供热系统是新建还是改造翻新等。

**制冷**

古代文明时就使用制冷了，那时所使用的制冷是天然的。罗马统治者们让奴隶们从高山上搬运冰、雪，用来保存食物，并在暑热时提供冷饮。当然，这种依靠自然资源制冷就地点、气温和范围而言是极其有限的。使用机械产生冷量的方式称为机械制冷，从 19 世纪 50 年代开始发展起来。当今，制冷工业是任何技术社会的庞大而重要的一部分，仅在美国制冷设备的年销售额就达到数十亿美元。

制冷的用途可简便地分为下列几类：家用、商用、工业用和空气调节。有时，把运输单独列为一类。家用制冷用于家庭食物的制备和保存、制冰和冷却饮料。商业制冷多用在零售店、餐厅和公共机关，与家用制冷的目的一样。食品工业中的工业制冷用于食品加工和制备，以及大规模保存。略举几项，这种制冷包括在食品冷藏冷冻厂、冷藏库、酿酒厂和乳制品厂中的应用。成百上千的其他工业也使用制冷，其中有制冰厂、炼油厂、制药厂等。当然，滑冰场也需要制冷。

制冷业广泛应用于民用舒适空调和工业空调中。工业空调用来为生产过程创造所需的空气湿度、温度和洁净度。计算机也需要一个可控制的环境。

制冷，通常所说的冷却过程，可更加确切地定义为“从物质中排除热量，使其达到或保持在一个理想的低温状态下，低于周围环境温度”。使用最广泛的机械制冷的方法称为蒸汽压缩系统。在此系统中，易挥发的液态制冷剂在一个蒸发器内蒸发，其结果是把热量从被冷却物质中排出(冷却)。为了维持蒸发过程和使制冷剂恢复使用，需要设置压缩机和冷凝器。另一种广泛使用的制冷方法称为吸收式制冷系统。在制冷过程中制冷剂蒸发(如同在蒸汽压缩系统中一样)，但这种蒸发是通过在另一种液体中吸收制冷剂来维持的。其他制冷方法有热电式、蒸汽喷射和空气循环制冷。这些系统仅用于特殊用途，它们的工作原理不在此解释。

蒸汽压缩系统的主要设备组件是大家所熟悉的蒸发器、压缩机和冷凝器。这些设备可能是分离的或整体式的(也称作整装的)。整体式设备是在工厂组装的。家用冰箱就是整体式设备的常见实例。整体式设备的明显优点就是更为紧凑，并在大批量生产时较便宜。

商业用制冷设备种类繁多，每种都有其特定的功能。开式冷柜，能进人的大冰箱和展品柜被广泛应用于食品服务业。自动制冰机、饮水冷却器和冷藏销售器也都是常见的设备。

空调包括内部环境空气的加热、降温、加湿、除湿和净化(过滤)。有时当谈论到两个学科之间的相互关系时，必须提到空调的一些内容。对空调所涉及的原理和设备的研究即便是对那些主要对制冷感兴趣的人来说也是很有价值的。

## Section B　地板辐射采暖

地板辐射采暖是通过一系列的加热管道循环热水，这些管道通常在铺地板的时候就被埋进去了。这些管道在两个送回水支管之间形成一个连续的环路。每个房间都有各自的管路循环方式，并且能够把热量准确地送到需要的地方。地板辐射采暖有许多优点，包括美观，没有占据墙壁空间的散热器。这样就可以更自由地按自己的喜好来装饰房间，如果采用一个高效率的蒸汽锅炉，地板辐射采暖与普通的采暖系统相比可节省 25%的运行费用。很容易就能达到这种程度的节能，甚至还能更节约一些。

现代人们要求，在人工环境中有高水平的热舒适性，与之相关联的是，减少对地球储存能量消耗的压力日益增长。现代技术在发展新型创新热源方面迈出了巨大步伐。然而，在热舒适和能源保护相结合方面，最大的进展还是现在地板供热加湿系统。高质量塑料管的出现使得用低温水在地板供热系统中成为可能。地板供热加湿系统完全可以满足新热源技术，地

板供热系统已完全发展成为适合于各种地板结构，把传导、辐射、对流等所有传热结合起来，从而适应整个建筑物内理想温度梯度的要求。这种安全、隐蔽、节约空间，并且防破坏和防受损的系统既敏感又节能，提供了被动的自动调节。

热舒适可以定义为：人们对热环境感到满意时的精神状态。研究表明，脚比头略微温暖时，人感觉更舒服。单独进行的实验表明，人可接受的最佳室内气候条件是地板温度范围为19～29℃， 头部位置的空气温度为20～24℃。

然而，由于个人兴趣爱好是一切人类活动必不可少的，因此不可能规定一套满足各种情况的环境条件。我们能够达到的最佳结果取决于5%的不满意因素。不存在使每个人都满意的温度。但是，我们可以以建立一个舒适区域为目标，使最大数量处于这个区域的人感到满意。

在辐射散热器或对流散热器的供热系统中，产生竖向温度梯度，地板处比头部冷。现代室内气候条件无疑需要一种与人类热舒适条件相匹配的供热系统，即热效应均匀分配在地面而不是头部。我们已经看到，温暖的脚部会产生良好的感觉，因此，让我们来考察一下，如果把整个地面加热到恰当的温度，将对室内气候产生什么影响。

我们已经设计到对建筑物标准的改进，然而无论怎么保温也不能改变物理学规律——热仍然上升。但是有效的绝热会把热量截留在对舒适无用的头部以上的区域，要解决这个问题涉及仔细研究我们可以利用的三种形式的热。辐射热提供了最令人满意的舒适感觉。有助于增加人们在春天阳光下散步的情趣，虽然环境温度只比冰点高几度。我们对传导热反应良好，给人一种好像抱着热水瓶或依偎在别人怀中而得到像猫似的愉快感觉。最后还有一种是空气温暖并使空气上升的辐射和传导效应而引起的热对流。通过综合使用这三种热，就可达到高水平的热舒适度。供热系统设计的正常标准是获得指定的气温。这个指定的气温是指在一定的室外气温下，抵消建筑物一定热耗后的气温。在设计地板辐射供热系统时，由于全面辐射程度较高以及温暖便利的地板导热，较低的空气温度也是可以接受的。

在现代保温良好的建筑物中，地板表面温度只需略高于空气温度就可以获得所需舒适因素。这些小的温差在整个建筑物中引起了轻微的低速对流。与其他形式的供热形式相比较，低速对流减少了空气中的灰尘量。不存在那种辐射像散热器或对流散热器后面那样的灰尘或污垢聚集而清扫不到的地方，而且运行成本也比较低。消除高速对流意味着在人头部空间将没有聚集的高温空气团。

加热地板是一个辐射面，辐射面上的物体将受到全方位辐射的益处。

高水平的辐射舒适意味着使用地板辐射供热系统时，其室内空气温度实际上可以略低于采用其他供热方法通常所需的温度。辐射、传导和对流综合起来，为健康和舒适创造了理想的热环境。

地暖是热从脚生，中医学称“脚为人体第二心脏”的“穴位密集区”。因此地暖能促进人体血液循环，增强内分泌，起到人体防病保健的作用，能起到冬天供暖，夏天防潮的作用，正确利用水系统地面辐射供暖至关重要，使用好了是绿色、环保、节能、保健，人居采暖的最好选择。地板辐射采暖系统的优点如下：

(1) 传热方式与热舒适度不同：依靠地面的低温辐射散热；

(2) 理想垂直温度场分布：垂直方向，上低下高；

(3) 减少空气垂直对流及室内扬尘；

(4) 水平温度场均匀：房间内同一水平上，温度基本相同；

(5) 减少干燥：在相同含湿量时，空气温度比传统采低；

(6) 隐形，无噪声采暖；

(7) 分户、分室控制，理想节能；

(8) 适用广泛的系统。

Section C　太阳能在建筑中的应用

地球接收来自于太阳的能量称为太阳能。自从有了太阳能，它直接或间接地为地球提供了几乎其他所有能量。众所周知，太阳的能量是巨大的。在美国，太阳能每天的辐射量为1400 Btu/ft$^2$(1 ft$^2$=0.0929030 m$^2$)，然而，1000 ft$^2$的面积每年可以接收大约5.11亿Btu (1 Btu= 1.05506 kJ)的能量。但是，太阳能是随着季节变化的，6～12月期间，太阳能的热量每天每平方英尺从2000 Btu至500 Btu不等。云量和地理位置等因素会影响被接收到的太阳能的总量。太阳能是取之不尽的、清洁的和可再生的能源，必将成为将来的主要能源。如何利用太阳能已经是各个国家的科学和技术工作者研究的热点。随着太阳能的发展和应用，太阳能供暖、太阳能提供生活热水和太阳灶等都是太阳能在建筑中的首次利用。

众所周知，能源的供给和成本已成为当今社会发展的主要因素。很显然，利用太阳能解决“能源危机”是有道理的。提出了许多保护现有资源和开发新能源的计划，在任何过程中尽可能地减少能源的利用。因此，应建立和发展能源工程。能源工程师的首要目的，就是为了在减少能源利用的同时还要保持产量不变甚至有所增加；第二个目的，是为了确定使用较少能源的方法是合算的。

同时，探寻理想的能源对解决能源危机也是非常重要的。对于一种理想的能源而言，要求在供应上是无限的，利用是广泛的，价格是低廉的；同时也不能增加地球的热量负担，也不能造成大气污染和水污染，太阳能能满足所有这些要求。在地球上，仅利用到达地球的一小部分太阳能就可以提供所有的能源需求。

太阳能是当今讨论的最流行的替代能源。关于太阳能，书中也有大量的记载和叙述。但是，许多人不了解它的可行性和局限性。

每年，大约有20%的国家能源用在建筑的供暖和制冷。太阳能是一种替代能源，可以减少我们对价格不断增加的有限的化石能源的依赖。

太阳能在建筑中的应用，不仅可以对建筑物供暖、提供生活热水，还可以利用太阳能来制冷。太阳能的能量是无限的，但是受技术和条件的限制，它的开发和利用是有限的。太阳能的利用需要大量的土地，并且对于一小块土地上太阳能的收集，将涉及经济和环境问题。第一，这种能量是来源于太阳的漫射，即它的传播非常的弱。因此，必须想办法把太阳光收集到一个地方。第二，这种被接收到的太阳能是间歇的，因为只有在白天才能收集太阳能，但是白天经常是被云彩所覆盖。因此，必须将收集到的太阳能储存起来。

太阳能系统可以储存能量。当太阳辐射在时间和需求上不同时，这个储热系统是最有用的。但是，许多系统在没有储热系统的情况下运行。例如，对于太阳能制冷系统，更高水平的太阳辐射通常出现在更高冷负荷的同一时刻。因此，该系统在没有储热的情况下能有效地运行。同样的情况也可能发生在太阳能热电联产系统中，或发生在提供了一个有用的，数量远远低于总负荷的能源系统中。储热的使用也将导致热损失。原则上，这些综合效应是积极的，以及太阳能可能高于无存储系统。为了确定储热利用的优势，应当对这两种系统(储热和无储热)进行评价。一个理想的储热系统能够接收热量，但是不增加其温度。

太阳能既可转化为电能，也可转化为热能。理论上，任何制冷技术都要它来驱动。一些关于太阳能的质量和数量的制约因素限制了太阳能的驱动潜力，甚至限制了太阳能的制冷技术。牢记太阳能发电和热机械系统的特点和简明扼要的理由，他们只能在有限的扩展中讨论。

电力驱动系统的特点是利用太阳能的方式来实现有限的有用的能力，且初投资相当高。目前，太阳能制冷主要有三种。第一，太阳能吸附系统；第二，太阳能吸附式制冷系统；第三，喷射式制冷系统。

总之，在空调系统中，太阳能的应用仍然有高的研究需求，且主要集中在太阳能的收集上，尤其是吸附式制冷技术。从环境角度看，太阳能制冷似乎是一个有希望替代常规电力驱动空调的系统，因为它能够减少二氧化碳的排放，可以消除氟氯化碳和氟氯烃。后者预计将明显影响到空调的发展。

## Grammar：科技论文的写作(Ⅰ)——论文体例

### Knowledge on Writing a Research Paper Ⅰ—Stylistic Rules of Paper

科技论文(science papers)是论述自然科学研究和技术成果的说理性文章。撰写英文科技论文的目的，是为了参与国际学术交流，如在英文期刊杂志上发表或在国际学术会议上宣读自己的科技论文，让同行了解和分享学术成果。为提高论文写作质量、减少撰写过程中的盲目性，有必要较系统地了解和学习英文科技论文的写作方法。

本章从科技论文的体例、标题与署名、摘要、正文的组织与写作和结语、致谢、参考文献等部分详细地介绍了科技论文的结构和撰写科技论文的技巧及注意事项。旨在希望读者能系统地学习英文科技论文的写作方法。本部分结合土木工程，介绍英文科技论文写作的一般方法；并通过实例，介绍写作要点和技巧。

国际标准化组织(International Organization for Standardization)、美国国家标准化协会(American National Standards Institute)和英国标准协会(British Standards Institute)等国际组织都对科技论文的写作体例(stylistic rules)做出了规定，其基本内容如下：

对于期刊类论文(Composition about Paper in Periodical)，主要部分包括：

- ✧ Title 标题
- ✧ Abstract 摘要
- ✧ Keywords 关键词，或主题词(Subjects)
- ✧ Main text 正文，包括
  - ◆ Introduction 引言
  - ◆ Material and method ,analysis of the theory, test procedure 材料与方法，理论分析或试验过程
  - ◆ Results 结果
  - ◆ Discussions(summary, Conclusions, Suggestion and Development) 讨论(总结，结论，建议和发展)
- ✧ Acknowledgments 致谢
- ✧ References(Appendix)参考文献(附录)

长篇科技报告(Science Report)包括科研成果(Research result)、学位论文(Thesis)等，主要由以下几部分组成：

- ✧ Front 前部，包括：
  - ◆ Front cover 封面，包括

    The title 标题

Contract or job number 合同或任务号
The author or authors 作者或合作者
Date of issue 完成日期
Report number and serial number 报告编号和系列编号
Name of organization responsible for the report 研究单位名称
A classification notice (confidential, secret, etc.) 密级(机密、保密等)

- ◆ Title page 扉页
- ◆ Letter of transmittal (Forwarding letter) 提交报告书
- ◆ Distribution list 分发范围
- ◆ Preface or foreword 序或前言
- ◆ Acknowledgments 致谢(可能没有)
- ◆ Abstract 摘要
- ◆ Table of contents 目录
- ◆ List of illustration 图表目录

✧ Main Text 正文

- ◆ Introduction 引言
- ◆ Analysis of the theory, test procedure and results with subheadings 理论分析、试验过程及结果(附子标题)
- ◆ Discussions (summary, conclusions) 讨论 (总结，结论)
- ◆ Recommendations (suggestion and development) 建议(建议和发展)

✧ Back 后部

- ◆ References 参考文献
- ◆ Appendix 附录
- ◆ Tables 表
- ◆ Graphics 图
- ◆ List of abbreviations, signs and symbols 缩写，记号和符号表
- ◆ Index 索引
- ◆ Back cover 封底

以上只是对科技论文和报告的框架规定，在实际写作过程中，不一定也不可能完全按照上述框架来编写，允许根据实际情况做出适当调整。

# Chapter 15

## Air-conditioning and Ventilating

### Section A Air Conditioning

The American Society of Heating and Air Condition Engineerings (ASHRAE) define **air conditioning** as: “The process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution to meet the requirements of the conditioned space.”

The science of air-conditioning may be defined as that of providing and maintaining a desirable internal atmospheric environment **irrespective of** external conditions. As rule ‘ventilation’ involves the delivery of air which may be warmed, while ‘air-conditioning’ involves delivery of air which can be warmed or cooled and have its **humidity** raised or lowered.

Air conditioning controls the temperature, moisture, cleanliness, and movement of indoor air. It cools the air when the weather is hot. It warms the air when the weather is cold. Comfort depends partly on humidity, and air conditioning removes moisture from the air or adds it as needed. Removing dirt and dust from air makes the air more healthful. By controlling air movement, air conditioning brings fresh air into a room and pushes out stale air. In all these ways, air conditioning provides air that makes people comfortable at work, at play, and while sleeping.

The desired atmospheric condition usually involves a temperature of 18℃ to 22℃ in winter and 21℃ to 24℃ in summer; a relative humidity of about 40 per cent to 60 per cent; and a high degree of air purity. This requires different treatments according to climate, **latitude**, and season, but in **temperate zones** such as England it involves:

In winter—A supply of air which has been cleaned and warmed. As the warming lowers the relative humidity, some form of **humidifying** plant, such as **spray** or a **steam injector**, with preheated and main heater whereby the humidity is under control, is generally necessary.

In summer—A supply of air which has been cleaned and cooled. As the cooling increases the relative humidity, some form of dehumidifying plant may be an essential. This dehumidifying is generally accomplished by exposing the air to cold surfaces or cold spray, whereby the excess moisture is condensed and the air is left saturated at a lower temperature. The temperature if the air has then to be increased, to give a more **agreeable** relative humidity, which can be done by warming or by mixing with air which has not been cooled.

Dehumidifying can also be brought about by passing the air over certain substances which absorb moisture. Thus, in laboratories, a vessel is kept dry by keeping a bowl of strong **sulphuric acid** in it or a dish of **calcium chloride**, both of which have a strong **affinity** for moisture. Silicagel, a form of **silica** in a fine state of **division** exposing a great absorbing surface, is used also for drying air on this principle, but this process is complicated by the need for re-generation of the medium by

heat and subsequent cooling, and is not generally used in comfort air conditioning applications.

The application of air-conditioning may be considered necessary to meet a variety of circumstances:

1. Where crowds of people **congregate** such as in restaurant, cinema, theatres and the like.

2. Where work has to be carried on in a confined space, the task being of a high precision and intensive character, such as in **operating theatres**, instrument assembly shops and the like.

3. Where the **exclusion** of air-borne dust is essential.

4. Where the type of building and usage thereof involves considerable **heat gains** such as in multi-storey office blocks with large glass areas subject to solar gain, and including heat-producing office machinery, computers, intensive electric lighting, etc.

5. The core areas of modern buildings planned in depth, where the **accommodation** in the core is remote from natural ventilation and windows and is subject to internal heat gains from occupants, lights, etc.

In **tropical** and sub-tropical countries, air conditioning is primarily required to reduce the high ambient temperature to one in which working and living conditions can be tolerable. In the temperature **maritime climate** of the British Isles and in similar parts of the world, long spells of warm weather are the exception rather than the rule, but modern forms of building and modern modes of living and working have produced conditions in which, to produce some tolerable state of comfort, air-conditioning in the best answer. Thus we find buildings of the present day incorporating to a greater or lesser extent, almost as a common rule, some form of air-conditioning. This great variety of applications has produced an almost equally great variety of systems, although all are fundamentally the same in basic principle: that is, to achieve a controlled atmospheric condition both in summer and winter, as referred to earlier, using air as the medium of circulation and environmental control.

The installation of complete air-conditioning in a building as a rule eliminates the necessity for heating by direct radiation, and it naturally incorporates the function of ventilation, thus eliminating the need for opening windows or reliance on other means for the introducing of outside air.

All air-conditioning systems involve the handling of air as a means for cooling or warming, dehumidifying. If the space to be air-conditioned has no occupancy, no supply of outside air is necessary, that inside the room being continually recirculated. In most practical cases, however, ventilation air for occupancy has to be included and in the design for maximum economy of heating and cooling, this quantity is usually kept to a minimum depending on the number of people to be served. Thus, in most instances it will be found that the total air in circulation in an air-conditioning system greatly exceeds the amount of outside air brought in and exhausted. Where, however, it is a matter of **contamination** of the air, such as in a hospital operating theatre, or where some chemical process or dust-producing plant is involved, 100 per cent outside air may be needed and no recirculation is then possible.

With a certain design of plant it is possible to arrange for 100 per cent outside air to be handled during periods of medium weather, such as in spring and autumn, when neither cooling nor heating is required, or at any other time when it can do useful cooling.

The basic elements of air-conditioning systems of whatever form are:

Fans for moving air;
Filters for cleaning air, either fresh or recirculate, or both;
Refrigeration plant connected to heat exchange surface, such as finned coils or chilled water sprays;
Means for warming the air;
Means for humidification; and/or dehumidification;
A control system to regulate automatically the amount of cooling or warming.

## Words and Phrases

air conditioning *n.* 空气调节
irrespective of 不论，不考虑，与……无关
humidity [hjuːˈmiditi] *n.* 湿度，潮湿，湿气
latitude [ˈlætitjuːd] *n.* 纬度
temperate zones 温带
humidify [hju(ː)ˈmidifai] *vt.* 使加湿
spray [sprei] *n.&v.* 喷射(器)，喷嘴；喷淋
steam injector 蒸汽喷射器
agreeable [əˈgriːəbl] *adj.* 适宜的，合意的
sulphuric [sʌlˈfjuərik] *adj.* 硫黄的，含多量硫黄的
sulphuric acid 硫酸
calcium [ˈkælsiəm] *n.* 钙
chloride [ˈklɔːraid] *n.* 氯化物，漂白粉
affinity [əˈfiniti] *n.* 吸附力
silica [ˈsilikə] *n.* 硅石，二氧化硅
division [diˈviʒən] *n.* 分布，单元
congregate [ˈkɔŋgrigeit] *vt.* & *vi.* (使)集合，聚集
operating theatres 手术室
exclusion [iksˈkluːʒən] *n.* 排除
accommodation [əˌkɔməˈdeiʃən] *n.* 住处(尤指仅供短期使用的)
heat gains 得热
tropical [ˈtrɔpikəl] *adj.* 热带的
maritime [ˈmæritaim] *adj.* 海的；航海的
maritime climate 海洋性气候
contamination [kənˌtæmiˈneiʃən] *n.* 污染，污染物

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. As rule ‘ventilation’ involves the delivery of air which may be warmed, while ‘air-conditioning’ involves delivery of air which can be warmed or cooled and have its ________ raised or lowered.

2. Where crowds of people ________such as in restaurant, cinema, theatres and the like.

3. Where the type of building and usage thereof involves considerable ________ such as in

multi-storey office blocks with large glass areas subject to solar gain, and including heat-producing office machinery, computers, intensive electric lighting, etc.

4. In ________ and sub-tropical countries, air conditioning is primarily required to reduce the high ambient temperature to one in which working and living conditions can be tolerable.

Ⅱ. Translate the following passages from English into Chinese.

When the weather is hot, most people enjoy eating in cool, air-conditioned restaurants. They sleep better in air-conditioned bedrooms. Airplanes, trains, ships, buses, and automobiles that are air conditioned make traveling more pleasant. Air conditioning helps keep homes clean by taking dirt from the air. It often relieves the discomfort of hay-fever victims, because it removes pollen from the air. Air-conditioned hospitals protect the health and improve the comfort of patients and hospital staffs.

In business and industry, air conditioning improves the efficiency of workers. Employees stay more alert and become less tired in air-conditioned offices and factories. They make fewer mistakes and have fewer accidents. Air conditioning also protects workers against high temperatures and harmful dust, smoke, and fumes. In stores and shops, air conditioning keeps merchandise clean. It also increases sales, because people like to shop in comfort.



## Section B Ventilation

All occupied spaces need **ventilation**, to maintain good air quality and a comfortable temperature. The purpose of ventilation is to maintain the building a prescribed condition and cleanliness of the air, in other words, the temperature, air velocity and concentrations. This task in the last analysis is resolved as follows. The **vitiated** air is removed from the building, **whilst** in its place clean air is introduced, often specially treated. On solution to the provision of ventilation is a mechanical system, either just using fans at **inlets** and/or extraction points to force a flow through the space, or fans coupled to an air handling unit which also controls the temperature and humidity of the incoming air. Of course, buildings without mechanical systems are still ventilated, but by a kind of air movement now called natural ventilation.

In essence this **boils down to** heat transfer and mass transfer between the incoming air and the air already within the building. If owing to **excessive** internal heat production the temperature of the air in the building tends to exceed the specified norms, cooler air is introduced and mixed with indoor air; the temperature of the air (owing to heat transfer ) then remains at the norm. If harmful gases or vapors are released, their concentration is held within specified limits by **dilution** with the clean incoming air.

More often than not mass and heat transfer take place **simultaneously**. For instance, the production of convective heat is very often accompanied by releases of gases and highly dispersed dust.

Ventilation can be affected by fans (mechanical ventilation) or by the difference between the densities of the columns of internal and external air, and also by action of wind (natural ventilation).

Ventilation can be general or local. Local extract ventilation is intended for removing polluted

air at source, to prevent the **dispersal** of **impurities** throughout the building. As much of the impurity as possible is removed in this way so that a minimum has to be **diluted** by incoming air. Local exhaust is not essentially ventilation proper.

Local ventilation thus limits the area of dispersal. This is assisted by use of fixed screens or by **air curtains**. The impurity is removed by **suction** of the polluted air, and this can be combined with a jet of air which **impels** the impurity towards the suction opening.

If air is **introduced into** a building, some excess pressure is set up in it. In the steady state this pressure will be such that the total quantity of air leaving the building through specially provided cents, or through random cracks in the external surfaces is equal to that which is introduced. A similar phenomenon will occur with the extract of air from the building. Here a negative pressure (**rarefaction**) is set up in the building, and in consequence air will be sucked in through gaps from outside and from adjacent rooms to take place of the extracted.

In certain cases this air has an **unfavorable** effect. For instance, if cold outdoor air enters a building in which much water vapor is produced it would create **mist** on mixing with the internal hot and moist air. If the inflow from outside or from adjacent rooms satisfies the **hygienic** requirements, it can be used to replace general mechanical ventilation by natural ventilation.

Ventilation is essentially the science of the control of air change in buildings.

In solving the problems of ventilation, the following questions arise: (1) What quantity of air should be supplied to the building per unit of time, what quantity should be extracted and how? (2) What characteristics should the incoming air have, and is **preliminary** treatment of the air necessary (heating, cooling dehumidifying, conditioning, dust removal, etc.)? (3) What should be the disposition of the inlets and outlets? (4) What should be the design of all the elements which determine the rate of air change?

To resolve the issues of general ventilation it is necessary to know the quantity of impurity entering per unit time into the air of building. It is also to know how the impurity is **dispersed** within the building, and how its distribution can be influenced by ventilation.

By extracting the air from areas with high concentrations of impurity, one considerably reduces the quantity of air needed for ventilation. For instance, in iron foundries the concentration of **carbon monoxide** (CO) in upper levels can be 0.04g/$m^3$, whereas in the work area it should not exceed the permissible norm 0.02 g/$m^3$. This **stratification** of the concentration is maintained by a supply of fresh air were supplied near the ceiling, in descending it would disturb the stratification and mix with the vitiated air, and with the same air change the concentration of CO in the work area be 0.03 g/$m^3$. To obtain a concentration of 0.02 g/$m^3$ one would have to increase the quantity of ventilation air by a factor of about 1.5. Thus the question of the estimated quantity of ventilating air is directly related to the question of arrangements for ventilation.

To calculate and design local ventilation in the form of air douches, it is necessary to know the properties of the jet, the laws governing the variation of its **velocity**, temperature and concentration and the geometric dimensions of the jet. To obtain the hygienically prescribed parameters of the air at the workplace, one needs to know the initial parameters of the air then find the forms of nozzles to produce a jet which would satisfy these requirements.

## Words and Phrases

ventilation [ˌventiˈleiʃən] *n.* 空气流通；通风设备，通风方法
vitiate [ˈviʃieit] *vt.* 削弱；破坏；损害
whilst [wailst] *conj.* 时时，同时
boil down to (使)煮浓成，浓缩成；浓缩，摘要；归结为……
inlet [ˈinlet] *n.* 入口，进口
simultaneously [siməlˈteiniəsly] *adv.* 同时地
dilution [daiˈljuːʃən] *n.* 稀释，稀释法，冲淡物
excessive [ikˈsesiv] *adj.* 过度的，过分的；极度的
impurities [imˈpjuəritiz] *n.* 不纯，不洁；杂质
dispersal [disˈpəːsəl] *n.* 散布，分散，消散，驱散，疏散
dilute [daiˈljuːt] *vt.* 稀释，冲淡；*adj.* 稀释的，冲淡的
air curtain 空气幕
suction [ˈsʌkʃən] *n.* 吸，抽吸
impel [imˈpel] *vt.* 推动、推进或敦促某人做某事
introduce into 引进，插入
rarefaction [ˌrɛəriˈfækʃən] *n.* 变稀薄，稀薄
unfavorable [ˈʌnˈfeivərəbl] *adj.* 不宜的，相反的，令人不快的
mist [mist] *n.* 薄雾，视线模糊不清；*vt &vi.*(使)蒙上薄雾，(使)模糊
hygienic [haiˈdʒiːnik] *adj.* 卫生的，清洁的
preliminary [priˈliminəri] *adj.* 初步的，预备的，开端的；*n.* 准备工作，初步行动
disperse [disˈpəːs] *vt.&vi.* (使)散开，驱散
carbon monoxide 一氧化碳
stratification [ˌstrætifiˈkeiʃən] *n.* 层化，成层，阶层的形成
velocity [viˈlɔsiti] *n.* 速度

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. All occupied spaces need ________, to maintain good air quality and a comfortable temperature.

2. In essence this ________ heat transfer and mass transfer between the incoming air and the air already within the building.

3. It is also to know how the impurity is _______ within the building, and how its distribution can be influenced by ventilation.

Ⅱ. Translate the following passages from English into Chinese.

Natural air change takes place in buildings as a result of wind and the difference in density between the indoor and outdoor air. Without control, such natural infiltration is haphazard, and the process can only legitimately be termed “ventilation” if the arrangements are designed to maintain the desired state of the indoor air under a variety of outdoor conditions.

If well designed, maintained and run, these systems can create a precisely controlled comfortable environment, but they are very expensive and energy intensive, and introduce other problems.

## Section C Ground-source Heat Pump Air Condition System

A heat pump is a refrigeration system whose purpose is to remove heat from one and supply is to another. In a **conventional** refrigerant, cooling is the only desired effect, while in a heat pump, either heating or cooling may be the desired effect. In most **residential** and **commercial** heat pump applications, heat is taken from the cooling outside air and "pumped" into the room for heating or heat is removed from the room and "pumped" to the warmer outside air for cooling. In the cooling mode the heat pump operates in heat pumps which use either **groundwater** or ice for either a source or sink, and there are many areas which could use these to advantage. At present, the vast majority of units are air to air heat pumps, river or lake to air heat pumps and **soil** to air heat pumps.

The working principle of a heat pump is similar to the **refrigerant**, the process of vapor compression heat pump are as follows. The working substance absorbs **a quantity of** heat from heat source (outdoor air or water) and gives it to the indoor one, which is the cold body (surrounding medium), and improve the room temperature.

In the 1950s, many heat pumps were installed in residences as the primary heating source. However, within a few years there are so many **renewable** energy sources used in heat pump, such as ground source heat pump, ground water source heat pump, surface water heat pump.

Ground source heat pump systems are "down to earth" heating, cooling and hot water systems designed to tap the earth's stored energy. The electrically powered unit pulls heat from the earth to warm your home during the winter. And, with the **flick** of a **switch**, the same system pulls heat from your home in the summer and transfers it to the earth. In addition, waste heat from the system can be used to heat water at a very low cost. Ground source heat pump systems provide **optimum** performance, **dependable** service, high efficiency and much more.

### How does a ground source heat pump system work

The down to earth energy option is an electrically powered system that capitalizes in the earth's moderate temperature. Water or an **antifreeze** solution is circulated through plastic pipes buried beneath the earth's surface. In the winter, this solution collects heat from the earth, carries it through the system and into your home. The ground source heat pump system provides you with constant warmth and comfort during the cold winter months.

In summer, the ground source heat pump system **reverses** itself to cool your home. Operating like the **refrigerator** in your kitchen, this system pulls heat from your home. The heat is then carried by the fluid in the pipes through the system and transferred to earth. A ground source heat pump system guarantees you constant cool relief during hot summer months. And, as an added benefit, you can **utilize** the waste heat from your home in the summer to heat water at substantial savings.

## What makes a ground source heat pump system so efficient

The down to earth energy option is the smart, efficient alternative to fossil fuels because the system works with Mother Earth by moving heat rather than making heat. By operating on the simple **premise** that heat always moves hot to cold, ground source heat pump systems can efficiently heat and cool your home by operating around the earth's moderate temperature.

Ground source heat pump systems are neatly-wrapped, energy efficient packages to help your household expenses. They offer you an economical method for managing your utility bills.

With a ground source heat pump system, you can escape the headache of balancing numerous utility bills. Each month you will receive one bill from your electric utility for your home heating, cooling and hot water cost.

No matter how hot or cold it is above ground, the temperature underground stays comfortable year round. But you don't have to live underground to be comfortable. In the winter, a machine called a ground source heat pump system can take heat from the ground and put it into your home. And in the summer it does the opposite. The ground source heat pump system pulls heat from your home and puts it in the ground. The ground source heat pump system saves money and energy. It is also quiet and small enough to fit your house.

## What can you expect from a ground source heat pump system

1. Saving. Ground source heat pump systems can put your home heating costs as much as 60 percent in the winter, reduce your home cooling costs up to 25 percent in the summer, and provide hot water for normal household use.

2. **Conservation**. Ground source heat pump systems work with the environment by utilizing the earth's moderate temperature to heat your home in winter and cool your home in the summer.

3. Cleanliness. Ground source heat pump systems, a clean **alternative** for heating and cooling, help preserve nature, a ground source heat pump system minimizes the present environmental problems like acid rain, air pollution or the destruction of the ozone layer.

4. **Durability**. Ground source heat pump systems last longer than conventional systems because they are self-contained systems housed entirely within your home and underground. These systems must endure.

5. Low maintenance. Ground source heat pump systems are not prone to breakdowns after frequent use like some conventional systems. Similar in concept to a refrigerator, a ground source heat pump system has few moving parts subject to breakdown. The heat exchanger in a ground source heat pump system, which transfers heat to and from the earth, is made of engineered plastic. It can operate efficiently fifty years after installation.

6. Low noise. Aside from cool relief and warm comfort, a ground source heat pump system will offer no additional **clues** to its hard work. Ground source heat pump systems have no noisy, **rattling** units to disturb your family or neighbors. Without these loud reminders, you may even forget your ground source heat pump system is there.

## Words and Phrases

conventional [kən'venʃənl] *adj.* 依照惯例的，依照传统的；常规的
residential [ˌrezi'denʃəl] *adj.* 住宅的，适于做住宅的；与居住有关的
commercial [kə'məːʃəl] *adj.* 商业的，商务的
refrigerant [ri'fridʒərənt] *adj.* 制冷的；*n.* 制冷剂
groundwater 地下水
a quantity of 一些
renewable [ri'njuəbl] *adj.* 可继续的，可续订的
flick [flik] *vt.* 轻打，轻弹；*n.* 轻打
switch [switʃ] *n.* 开关；改变，转变；*vt. & vi.* 转变，改变
dependable [di'pendəbl] *adj.* 可信赖的，可靠的
optimum ['ɔptiməm] *adj* 最适宜的；最有利的
antifreeze ['æntifriːz] *n.* 防冻剂
reverse [ri'vəːs] *vt.&vi.* (使)反转，(使)颠倒，(使)翻转；*adj.* 相反的，颠倒的，反向的
refrigerator [ri'fridʒəreitə] *n.* 冰箱
utilize ['juːtilaiz] *vt.* 利用，使用
premise ['premis] *n.* 前提
conservation [ˌkɔnsə'veiʃən] *n.* 保存，保护；对自然环境的保护
durability [ˌdjuərə'biliti] *n.* 经久，耐久力
heat exchanger 换热器
clue [kluː] *n.* 线索，提示；*vt.*〈非正〉为……提供最新情况(消息等)
rattling ['rætliŋ] *adj.* 咔嗒咔嗒的，活泼的，很好的；*adv.* 极佳，很，非常

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. In most ________ and ________ heat pump applications, heat is taken from the cooling outside air and "pumped" into the room for heating or heat is removed from the room and "pumped" to the warmer outside air for cooling.
2. The working principle of a heat pump is similar to the ________, the process of vapor compression heat pump are as follows.
3. Water or an ________ solution is circulated through plastic pipes buried beneath the earth's surface.

Ⅱ. Translate the following passages from English into Chinese.

Heat pumps have been successfully employed in commercial buildings for many years. These units are used in transferring energy from cooled to heated areas. In a typical large building, the interior zones are often cooled throughout the year while heating of the zones on the building perimeter.

Absorption heat pump is also a popular heat pump, and it may be more cost-effective in many locations. An absorption heat pump extracts heat from a low-temperature heat source, such as waste heat or surface water, and delivers its heat output at a higher temperature for winter heating.

# 参 考 译 文

## 第 15 章　空气调节和通风工程

Section A　空气调节

美国供热、制冷与空调工程师学会(ASHRAE)定义空气调节为“空气处理过程，同时控制空气的温度、湿度、洁净度以满足室内环境的要求。”

空气调节科学可以科学定义为不论外界条件如何，都可以提供和保持一个理想的内部空气环境。作为一项规则，“通风”涉及被加热空气的传递，而“空气调节”涉及被加热空气或者被冷却空气的传递，空气同时被加湿或者除湿。

空调控制温度、湿度、清洁度和室内空气的流动。当天气热时，它可以冷却空气。当天气寒冷时，它可以加热空气。舒适度取决于湿度，根据需要空调对空气加湿或者除湿。从空气中去除污物和尘埃使空气更健康。通过控制空气流动，空调将新鲜空气送入室内，并将不新鲜空气排出。通过这些方法，空调使人们在工作、游戏、睡觉时更加的舒适。

理想的大气状态通常是指冬季大气温度 18～22 ℃ ，夏季大气温度 21～24 ℃；相对湿度约 40%～60%；以及空气高清洁度。根据气候、纬度、季节、需要不同的处理方法，但在温带地区，如英格兰，它涉及以下因素。

在冬季供给已经净化和加热的空气。由于加热空气使得相对湿度降低时，伴随着预热器和主要加热器控制湿度，某种形式的加湿设备，如喷雾或蒸汽喷射器，通常是必要的。

在夏季供给已经净化和冷却的空气。由于冷却增加了相对湿度，某种形式的除湿设备可能是必不可少的。除湿一般通过将空气与表冷器接触或喷冷水，在较低温度下，空气达到饱和而多余的水分凝结。然后，可以通过加热或与没有被冷却的空气混合使空气温度升高，以提供更加满意的相对湿度。

除湿还可以使用某些物质通过空气来吸收水分。因此，在实验室中，通过一碗强硫酸、或一盘氯化钙能够使一个容器一直保持干燥，两者对水都具有很强的吸附力。硅胶，一种形式的二氧化硅，在非常好的分布状态下暴露很强的吸附表面，原理上可用于干燥空气，但这一过程很复杂，需要通过加热重新生成介质，随后再冷却，一般不在舒适性空调中应用。

遇到下面一些情况时，使用空调可能会被认为有必要的：

1. 人群聚集的地方，如在餐厅、电影院、剧院等。

2. 在特定的空间里工作，具有高精度和密集的特点，如手术室、仪器装配车间等。

3. 必须排除空气传播的灰尘的地方。

4. 有相当大量得热的这类建筑，如装有大型玻璃的多层办公大楼的太阳日照得热量，包括散热的办公机械、计算机、密集的电力照明等。

5. 现代建筑中设计的地下室核心领域，这里的房间远离自然通风和窗户，其负荷取决于住户、灯光等。

在热带和亚热带地区，空调主要用于降低高温环境，改善工作与生活条件。在不列颠诸岛还有其他类似的分布在温带海洋性气候的地区，由于温度适宜，本来不需要空调，但由于现代建筑的构造以及现代生活、工作方式的影响，要获得适宜的环境，还是得使用空调。因此，我们发现现代建筑或多或少地和空调的某些形式相关，这几乎成了一个普遍规律。大量不同的方案产生出大量相应的系统，虽然说从基本原理来看它们都是相似的，也就是说：要

在冬季和夏季都取得一个可控制的温度条件——正如上文中提到的那样——就要利用空气作为控制室内气流循环和环境的媒介。

建筑中的空调系统安装完成，就可消除辐射得热，可实现通风换气，从而无需开窗或依靠其他手段来引入室外空气。

没有设置空调的房间，无需引入新风以保持流通。但在大多数实际情况下，必须考虑通风，并且设计最经济的冷热负荷，通风量要取决于人员的需求。因此，在大多数情况下，我们发现，空调系统中的空气总量大大超过被引入和消耗的室外空气的量。但在存在污浊空气的区域，如医院、剧院、化工或产生粉尘的工厂等，需要全新风，无需室内循环。

在温和的季节里，例如春季或者秋季，当既不需要冷却又不需要加热时，或在可以进行有效冷却的其他任何时候，对某些设备设计可能安排100%的室外空气进行处理。

空调系统基本的组成形式是：

移动空气的风扇；

清洁空气的过滤器，无论是净化或再循环，或两者都有；

制冷装置连接到热交换表面，如肋片盘管或冷水喷淋；

加热空气的方法；

加湿、或者除湿的方法；

一个可以自动调节制冷量或者制热量的控制系统。

Section B　通风工程

只要有人居住的地方就需要通风，以维持良好的空气品质和舒适的温度。通风的目的是使建筑物内的空气保持某种规定状态及其清洁度，即保持温度、空气速度和浓度。归根结底，达到此目的的解决办法是：把污浊的空气从建筑物排出，而通常将特殊处理的干净空气引入室内取而代之。一种通风的解决方案是使用机械系统：要么就在入口和(或)抽气点处使用风机，强制产生气流流过空间，要么利用风机组合空调装置，这种空调装置也能控制外部进入的空气的温度和湿度。当然，不用机械通风系统的建筑物仍可以通风，不过这时的通风现在被称之为自然通风，它是一种空气运动的通风方式。

从本质上讲，通风可以归结为进入建筑物内的空气和原来空气之间的热量和质量的传输。如果由于内部热量的过度产生，建筑物内的空气温度趋向于超过规定的标准，将较冷的空气引入，并和室内空气混合，使空气温度由于热传输而保持为标准值。如果有害气体或者蒸汽释放出来，则有清洁空气稀释，使浓度保持在规定的极限范围之内。

质量传递和热量传递往往同时发生。例如，对流热的产生常常伴随着各种气体和高度分散的灰尘的释放。

通风可以由风机作用，或由内部和外部的空气密度差作用，也可以由风作用。

通风可以是全面的，或是局部的。局部抽气通风目的是从污染源处排除污染的空气，防止污染物扩散到整个建筑物内。尽可能多地将污染物以这种方式排除，使最小量的污染空气用送入的空气稀释。局部排风实际上不是真正的通风。

因此，局部通风只是限制了污染物扩散的范围。这种方法通常辅助以固定屏板，或空气幕。污染物通过抽走污染空气而得以排除。这可以与把污染物趋向抽气口的空气射流相结合。

如果把空气引入建筑物内，则室内就形成某种超压，在稳定状态下，当通过专设的通风孔或建筑物外表面上不规则的裂缝而排出的空气总量和进入屋内的空气总量相等时，便保持一定的压力。从建筑物抽排空气也会产生同样情况。这时，建筑物内形成负压，导致通过空隙从外部和相邻房间吸入空气来取代抽走的空气。

在某些情况下，这种空气有不利的影响。例如，如果外部冷空气进入有大量水蒸气生成

的建筑物，则在与屋内的热而湿润的空气混合时会产生薄雾。如果从外部流入，或从相邻房间流入的空气满足卫生要求，那么可以利用自然通风取代全面的机械通风。

通风实际上是控制建筑物内换气的一门学科。

在研究通风课题时，会出现以下问题：(1) 单位时间内应该有多大量的空气供入建筑物内？(2) 进入的空气应该具有何种特征？空气的预先处理是否有必要(加热、冷却、除湿、调节、除尘)？(3) 进风口和排风口应该如何布置？(4) 应该如何设计限定换气率的各种要素？

为了解决全面通风问题，必须了解单位时间内进入建筑物内空气中污染物的数量，了解污染物在建筑物内是如何扩散的，同时通风怎样影响其分布等问题也是很重要的。

把空气从污染物浓度高的区域排出去可大大减少通风所需要的空气量。例如，在铸铁车间上部一氧化碳的质量浓度可能是 0.04 $g/m^3$，而在工作区就不应超过允许标准质量浓度 0.02 $g/m^3$。这种浓度分层现象是靠在地面上供给新鲜空气，并从高处抽走污浊空气来保持的。假定在靠近天花板供入新鲜空气，当它下沉时，会打乱浓度分层现象，并与污浊空气混合，且以同样多的换气量，使工作区的一氧化碳的质量浓度为 0.03 $g/m^3$。为了获得 0.02 $g/m^3$ 的浓度，必须增加约 1.5 倍的通风空气量。因此，预测通风空气量与通风的配置有直接关系。

为了计算和设计喷淋式的局部通风，必须了解射流的性质，控制射流的速度、温度、浓度和几何尺寸等变化的规律。为了使工作区空气符合卫生规定的参数，首先要掌握空气初始参数，然后选择喷嘴形式，使其生成满足上述要求的射流。

## Section C　地源热泵空调系统

热泵是一种制冷系统，其目的是将一个物体热量传递给另一物体。对于传统的制冷剂，制冷是唯一预期的效果，而对于热泵，无论是加热还是冷却，都可能是预期的效果。多数住宅和商业楼运用热泵，把热量从室外冷空气中抽到室内用于制热，或者是把热量从室内抽到室外热空气中用于制冷。在制冷方式中，热泵使用地下水或者是冰来作为冷热源或者是冷热槽来运转的，而且，有很多领域可以利用这些优势。目前，绝大多数单位使用的是空气—空气热泵、河水或湖水—空气热泵和土壤—空气热泵。

热泵的工作原理类似于制冷剂，热泵蒸汽压缩的过程如下：工作物质从热源(室外空气或水)吸收大量的热量提供到室内，这是冷源(周围介质)，并提高室内的温度。

在 20 世纪 50 年代，许多住宅区安装了热泵作为主要热源。然而，在几年之内有如此多的可再生能源用于热泵，如地源热泵、地下水源热泵、地表水热泵。

地源热泵系统是设计用“地下土壤”进行加热、冷却和热水系统，旨在利用地球储存的能源。在冬季，电力系统将土壤里的热量拉动，使您的屋里温暖。而且，在夏季，轻弹开关，相同的系统将您屋里的热量转移到土壤。此外，系统里的余热可以以很低的成本被用来加热水。地源热泵系统可以为您提供最佳的性能、最可靠的服务、最高的效率和更多优良品质。

### 地源热泵系统是如何工作的

地能是用电力驱动的一个系统，利用地下土壤的温和适中的温度。水或防冻液通过埋在地表的塑料材质的管子进行循环。在冬季，这种解决方法从地上收集热量，通过系统携带热量并送入到您的家里。地源热泵系统在冬季为您提供恒定的温暖和舒适的温度。

在夏季，地源热泵系统反过来冷却您的屋子。运作系统就像您厨房里的冰箱，这个系统将您屋里的热量驱逐出去。然后，热量通过管道系统里的流体被携带转移到地底下。在炎热的夏季，地源热泵系统能够保证您一直凉爽舒适。此外，还有一个优点是，在夏季，您屋里的余热可以用来加热水，从而节省开支。

**是什么使地源热泵系统如此有效**

选择地能是明智的、高效的，用地能替代矿物燃料，因为该系统是与大地转移热量而不是制造热量来工作的。按照热量总是由热的传递给冷的这个简单基本的前提，地源热泵系统通过地下适宜的中等温度能有效加热和冷却您的房间。

地源热泵系统是包装整齐的、有效的能源软件包，可以帮助节约您的家庭开支。它们为您提供了一种经济的方法来管理您的电费。

拥有地源热泵系统，您可以摆脱令人头痛的开支利用。每个月，您将收到从电力公司在您家取暖、制冷和热水中节省的钱。

不管地面温度如何过高或过低，地下的温度常年保持舒适恒定。但是，您不必为了舒适的生活住在地下。在冬天，一台地源热泵系统的机器可以从地下得到热量并把它送到您的家里。在夏天情况正好相反。地源热泵系统提取您家里的热量并把热量投入到地下。地源热泵系统可以节省资金和能源，它也没噪声并且结构轻巧，适合您居家使用。

**你期望地源热泵系统什么**

1. 节约。在冬季，地源热泵系统的开支是您取暖费的 60%，在夏季，可以将您家里的冷却成本最多减少到 25%，并提供日常热水供应。

2. 养护。地源热泵系统和周围环境通过利用地下土壤的适当温度来工作，使您的屋子冬暖夏凉。

3. 清洁。地源热泵系统是加热和冷却时干净的选择，它有助于保护自然环境。地源热泵系统能够减少目前的环境污染问题，如酸雨、空气污染或臭氧层的破坏。

4. 耐用性。地源热泵系统的寿命长于常规系统，因为它们是自成一体的系统，完全的设置在家里和地下。这些系统肯定耐用。

5. 低维护。地源热泵系统不像常规系统那样在频繁的使用后容易受到损坏。在观念上和冰箱相似，地源热泵系统运动部件很少出现故障。将热量传给地下，或者吸收地下的热量的地源热泵系统的换热器，它是工程材料材质的。它的寿命自安装后可以有效运作 50 年。

6. 低噪声。除了清新凉爽和温暖舒适，地源热泵系统不会提供任何额外的工作负担。地源热泵系统没有任何噪声，不会打扰您的家人或邻居。没有这些噪声的提醒，您甚至可能忘了地源热泵系统的存在了。



## Grammar：科技论文的写作(II)——标题与署名

### Knowledge on Writing a Research Paper II—Title and Sign

论文标题属于特殊文体。一般不采用句子，而是采用名词、名词词组或名词短语的形式，通常省略冠词。从内容上，要求论文标题能突出地、明确地反映出论文主题。具体而言，在拟定论文标题时应注意以下几点：

(1) 恰如其分而又不过于笼统地表现论文的主题和内涵；

(2) 单词的选择要规范化，要便于二次文献编制题录、索引、关键词等；

(3) 尽量使用名词性短语，字数控制在两行之内。

**【例 1】** Bayesian Technique for Evaluation of Material Strengths in Existing Structures

采用贝叶斯技术评估既有结构的材料强度

1. 标题(Normal Format of Writing Title)

对题名的书写格式，目前常用的有以下几种：

(1) 标题文字全部大写。

【例 2】 RELIABILITY ASSESSMENT OF PRESTRESSED CONCRETE BEAMS

预应力混凝土梁的可靠性评估

(2) 标题主要单词首字母大写，其余为小写。

【例 3】 NONLINEAR ANALYSIS OF SPACE TRUSSES

空间桁架的非线性分析

(3) 标题主要单词首字母大写，其余小写。

【例 4】 Bridge Live-Load Models

桥梁活载模型

(4) 标题首单词首字母大写。

【例 5】 Sustainable development slowed down by bad construction practices and natural and technological disasters

不良施工、自然灾害和技术事故对可持续发展的延滞

2. 署名与作者信息(Sign and Information of Author)

一般，紧跟在论文标题之后的是论文署名和有关作者的信息，如作者单位、通信地址(近年来还包括 email 地址，个人主页的网址)、职称、学衔或会员情况等。按照英语国家的习惯，论文署名时名在前(可缩写)，姓在后；但为了便于计算机检索，也有姓在前，名在后的情况(参考文献中的作者姓名排列就是这样)。有关作者的信息有时放在署名之后，有时放在论文第一页的页脚，有时放在论文的末尾，有时还分开编排，这要视论文载体的具体要求而定。

(1) 作者信息紧接在署名之后。

【例 6】 Developing Expert Systems for Structural Diagnostics
and Reliability Assessment at J.R.C

A.C. Lucia

Commission of the European Communities, Joint Research Center, ISPRA Establishment, 21020 ISPRA(VA), Italy

(2) 作者信息放在论文第一页的页脚。

【例 7】 BRIDGE RELIABILITY EVALUATION USING LOAD TESTS

By AndrzejS.Nowak[1] and T.Tharmabala[2]

在论文第一页的页脚：

[1] Assoc. prof. of Civ. Engrg. , Univ. of Michigan, Ann Arbor, MI48109

[2] Res. Ofcr. , Ministry of Transp. and Communications, Downvsview, Ontario, Canada M3M 1J8

注意，在作者信息以及参考文献内，为节省篇幅，会采用较多的甚至不常见的缩写。如上例中的 Assoc 为 Associate，Civ 为 Civil，Engrg 为 Engineering，MI 为 Michigan，Res 为 Research，Ofcr 为 Officer，Transp 为 transportation 等。

# Chapter 16

# Emerging Role of Management in Civil Engineering

## Section A Construction Safety Management

### The Construction Industry

The construction sector is an important part of the economy in most countries. But the construction industry is statistically one of the most hazardous industries in many countries and regions. It is generally considered to be dangerous, dirty, hard and unreliable. For example, in Taiwan, approximately 60% of fatal accidents in all industries between 1999 and 2001 arose in the construction industry. With the rapid increase of Chinese construction activities, construction safety has become a big concern because worker injuries cause **tremendous** losses. In 2004, the number of workers in the Chinese construction industry was 25.58 million (National Bureau of Statistics of China 2005). And in recent 5 years, there are averagely 1300 construction workers are killed in work-related accidents each year.

Death rates within the construction industry around the world may indicate an inherently poor safety risk management culture. Each year, between 1986 and 1992, the UK construction industry has averaged 10 fatalities per 100,000 employees compared with an average of 2 per 100,000 for all other industries.

The characteristics of modern industry are large-scale, high-level automation and complex processes. The procedures and processes are related to, influenced and restrained by, each other. Once an accident occurs, serious affects will be caused to the lives and health of employees, and manufacturing facilities will also be heavily damaged. Construction site safety is of great importance to construction companies. Besides causing worker injuries, construction accidents also delay project progress, increase costs, **civil penalties** and damage the reputation of the contractors.

The construction process involves hazardous activities such as working at height, manual handling, exposure to hazardous materials, demolition, frame erection, lifting operations, **scaffolding** and **groundworks**. The industry is prone to ‘boom and bust’ cycles, under-production and over-capacity, intermittent work and climatic influences. Consequences of these negative characteristics of the construction industry include unnecessary financial and human loss.

### Cost of Accidents

All accidents affect the bottom line (profit). Accidents are those occurrences that result in loss

of production, illness or injury, damage to equipment or property, and near misses. Incidents cannot just be measured simply in workers' compensation costs. These incidents damage the continuity of the job site, which causes lost time, lost wages, the breakup of a crew or the loss of a key person, property loss in the form of damage to machines and equipment, and **culminates** in the supervisor's time lost during an incident investigation or an **OSHA** investigation/inspection which results in the cost of **citations** and **violations**, as well as the cost in the form of legal issues and fees. Also, insurance premiums, as well as worker's compensation experience rates, will be increased. There is also the cost of damaged property, new procedures, new equipment, labor issues, and the contractors' valuable time.

As can be seen, the cost of accident is not fully measurable, but the picture is very clear. These costs can definitely impact the efficiency and effectiveness of a construction operation, but oftentimes could be avoided by giving safety and health some attention and support on construction job sites.

## The Safety Program

More and more companies are recognizing the need to formulate and administer an organized, well-thought-out safety program. Not only does an employer have a legal and moral responsibility to provide a safe working environment, but safety makes economic sense. Lost workdays due to accidents can cause disruptions in work crew makeup and can lower the efficiency of the crews. The soaring rates of both commercial liability insurance and workmen's compensation insurance are dramatic indicators of the industry's **propensity** for injuries and an individual company's good and bad accident record.

An effective safety program requires that top management be wholeheartedly behind the program and, when visiting job sites, wear **hard hats**, **safety goggles**, or any other **designated** safety equipment. Only then will workers see that management is firmly committed to the safety program. A basic safety program consists of the following components:

- organization of a safety program;
- administration of the program;
- training and safety meetings;
- emergency situation procedures;
- accident reporting requirements;
- job safety standards;
- fire prevention policies.

## Personnel Training

Safety procedures consist of skills that must be learned, and it is unfair to assign responsibility for **safety practices** and **enforcement** to a job superintendent who has had very little or no training in safety techniques. Few people would wholeheartedly participate in such programs if they did not fully understand how to handle the responsibility that comes with the authority.

Training can be accomplished in several ways. Safety seminars can be held at each job site, or all participants in the administration of the program can **congregate** in one location for instruction. Insurance **underwriters** are usually most anxious to conduct, or at least participate in, these sessions.

## Safety Meeting

In order for a safety program to be effective, people have to be constantly reminded of good safety practices, and they have to be aware of job and company accident records. One approach to heightening that awareness is to conduct regular safety meetings at the job site. These meetings, known as “tool box meetings,” can be conducted by either the job **superintendent** or the project manager. The meetings should be held on company time, and they are to be attended by all personnel employed on the job. It will be necessary to obtain the permission of each subcontractor to include his workers in these meetings.

At the initial meeting, the purpose and objective of the safety meetings should be outlined, the safety program should be explained, and the ground rules for safety practices should be established.

## Safety Culture

A vital **ingredient** in generating safe working is the safety culture which **pervades** a construction organization. Safety culture is a mixture of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and **proficiency** of, an organization’s safety management. In short, the safety culture is the distillation of beliefs that members of an organization share about safety. This culture cannot be manufactured and installed; it has to grow organically, it will take time to take root. The reward is that those who work in the firm do not merely comply with safety rules and regulations but have internalized the need for safe working. The features of a safety culture can be identified:

- leadership and commitment to safe working from the top which is genuine and visible;
- there is a long term strategy;
- there must be a policy of high expectations, conveying a sense of optimism about what is possible which is supported by appropriate procedures;
- a sense of ‘ownership’ of safety standards with widespread involvement in the policing and training for safety;
- targets established for safety performance and measured regularly to compare performance with the targets set;
- good safety behavior should be a condition of continuing employment and considered in annual **appraisals;**
- a management information system which includes the **evaluation** of safety as well as commercial information.

In this way, construction firms can move towards a safety culture—it is an effective, **resilient** and painless way of improving the safety climate in an organization. The safety officer will be an important agitator for a strong safety culture.

## Safety Evaluation

Safety evaluation, also called risk assessment, aims to identify and analyze risk factors existing in a system with the principles and methods of system safety engineering for the purpose of the realization of system safety. It will determine the possibility and severity of accidents and

**occupational hazards** in the system, which is useful to provide a scientific basis for the management and decisions of accident prevention.

Safety pre-evaluation (SPE) is a type of safety evaluation which is used to analyze and predict risk of hazards existing in a construction project and provide reasonable and practical proposals for safety technology and safety management based on the feasibility study report of the construction project. In fact, it is a predicted assessment by analyzing the hazards of a project with the principles and methods of safety evaluation in the earlier stage of a construction project. SPE of a construction project is a very important technical support for the implementation of the production guidelines of “Safety First, Prevention First” and also a main means of supervision and management on safety in production.

The core of SPE is to carry out qualitative and/or quantitative analysis on the risk factors of a system. In other words, it assesses the possibility and severity of the occurrence of accidents and hazards in terms of a certain system range. SPE can provide prevention and reduction **countermeasures** with respect to the main hazardous factors and their potential consequences, and can assess whether the system can meet the safety requirements of related national laws and regulations after such measures are applied. Thus, the conclusion can be made on how to design and operate the construction projects to meet the safety requirements.

## Words and Phrases

tremendous [tri'mendəs] *adj.* 极大的，巨大的
culminate ['kʌlmineit] *vt.* & *vi.* 达到极点
civil penalty 民事罚款
citation [sai'teiʃən] *n.* 引用，引证，引文；表扬，嘉奖
violation [ˌvaiə'leiʃən] *n.* 违反，冒犯，侵害
propensity [prə'pensiti] *n.*倾向，爱好，嗜好，脾性
designated 指定的，派定的
scaffold ['skæfəuld] *n.* 脚手架
groundworks 土方工程
OSHA *abbr.* Occupational Safety and Health Act <美>职业安全与卫生条例[管理局]
hard hat 安全帽
safety goggles 防护眼镜
congregate ['kɔŋgrigeit] *vt.* & *vi* (使)集合，聚集
proficiency [prə'fiʃənsi] *n.* 熟练，精通
enforcement [in'fɔːsmənt] *n.* 强制，实施，执行
superintendent [ˌsjuːpərin'tendənt] *n.* 主管，负责人，管理者
underwriter ['ʌndəraitə] *n.* 保险商；保证人
ingredient [in'griːdiənt] *n.* (混合物的)组成部分；组分，要素
pervade [pə(ː)'veid] *vt.* 遍及，弥漫，充满，渗透
appraisal [ə'preizəl] *n.* 估计，估量，评价
resilient [ri'ziliənt] *adj.* 弹性的；有弹力的，适应性强的
safety practice 安全措施
evaluation [iˌvælju'eiʃən] *n.* 估价，评价，赋值

countermeasure [ˈkauntəˌmeʒə] *n.* 对策，反措施
occupational hazard *n.* 职业病

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. It is generally considered to be ________, ________, ________ and ________.
2. The characteristics of modern industry are ________, ________ automation and ________processes.
3. There is also the cost of damaged ________, new ________, new ________, labor ________, and the contractors' ________ time.
4. Insurance underwriters are usually most ________ to conduct, or at least participate in, these sessions.
5. In other words, it assesses the ________ and ________of the occurrence of accidents and ________in terms of a certain system range.

Ⅱ. Translate the following passages from English into Chinese.

In some construction companies, the administration of the safety program may fall to a safety director; other companies give the responsibility to the general field superintendent. No matter how the safety program is administered, however, the project manager will become an integral part of it and must be alert to safety procedures.

A company safety program does, of course, cost money. A common rule of thumb is that an effective company safety program will have a cost of about 2.5 percent of direct labor expense. The fact is, however, an important distinction that must be recognized between safety costs and other items of company expense. The distinction is that the spending of one dollar for safety can save the contractor two dollars. Although this ratio is only figurative, it has been well demonstrated that the costs of safety programs are more than compensated for by savings on accidents that do not happen.





# Section B Construction Management

## Introduction

The most basic definition of a project is some form of human activity that has a beginning, a productive middle phase and an end, creating something that has not previously existed. In the construction business, the project will create a building or a work of civil engineering construction. The definition is important, because it emphasizes the transitory nature of the construction process—construction companies arrive on site, build, and leave for the next project. The project site may be far from the headquarters of the construction company, and in the case of major international construction projects, it may well be in another country, operating in a social, economic and physical environment that is quite different from that within which the construction company is based. No other industry sets up a new factory, in a new place, for every product it

produces. Few make their products in the open air, adjusting their manufacturing methods to the climate and season.

Construction management (CM) entails the planning, scheduling, evaluation, and controlling of construction tasks or activities to accomplish specific objectives by effectively allocating and utilizing appropriate labor, material, and time resources in a manner that minimizes costs and maximizes customer/**owner** satisfaction.

## The Goals of Project Management

Fig. 16.1 illustrates what all clients require from a construction company: a project completed on time, within **budget**, and to the required technical performance and quality standards. Clients are increasingly demanding that all three of these aims are achieved, and are increasingly unwilling to accept the "management **compromise**", which was common practice until quite recently. Quality is an especially important requirement. If the construction contractors fail to manage the project effectively, the only "compromise" that they can make is to spend more of their own money to achieve the other two aims.

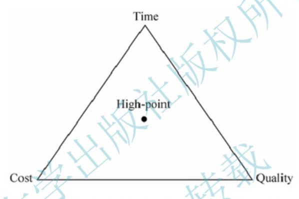



Fig 16.1 Project objectives and their relationship



**1)** ***Budget.*** All work should be carried out against budgets. For a small builder this is just a list of jobs annotated with their estimated labour and material costs. For larger projects built by some of the bigger contracting companies, budgets will exist not only for jobs, but also for each of the head office departments involved and for other elements of the project and its organization. When actual costs exceed their budgets the contractor's profits are at risk. If the losses are very great, the contractor's business is at risk. The project might even have to be aborted, or restarted with a fresh contractor.

**2)** ***Time***. Time is often the most important objective of all. Time is an **irreplaceable** resource. A job that has missed its target date is late and that, unfortunately, is that. Costs tend to follow time and grow with time. A project that is finished late usually also overruns its budgets. So, controlling progress against the plan goes a long way towards controlling the costs of a project.

**3)** ***Quality***. The project should meet all **specification**s in respect of appearance, safety, **reliability** and performance.

**4)** ***Balancing the three primary objectives***. The three primary objectives are all **interrelated**. For example, time is usually related to costs. Project owners sometimes have to decide whether or not more emphasis should be given to one of the objectives, perhaps at the expense of the other two.

A special word is needed in this context about quality. A good, generally accepted definition of quality is that the object should be fit for its intended purpose. Of course every project must be fit for its intended purpose. So, 'quality' as such is an objective that is not negotiable: it is an absolute requirement and cannot be part of an objectives balancing exercise.

However, consider two different building schemes, each for a **block** of **residential** apartments. One is a luxury block where the developer expects to receive high rents from rich tenants. The other is a local authority project to provide basic accommodation for families with low or no means of support. One of these developments might have **en-suite** bathrooms with **gold-plated** fittings, **marble** floors, two garage spaces per flat, with the whole set in landscaped grounds. The local authority building will probably display **concrete** as one of its main features. But each of these projects is intended for a different purpose and, if fit for that purpose when finished, can be called a quality success.

Here are some examples where balancing decisions must be made:

(1) A nuclear power station must above all be reliable and safe. So the quality objective is **paramount**.

(2) A project to build a stadium for the Olympic Games must be ready in time for the games. So time is the paramount objective.

(3) A hospital management group needs to build an extension to act as consulting rooms and waiting areas for **outpatients.** The budgets are very limited. So the specification must be **trimmed** so that the cost is as low as possible.

## Project Participants

***Owners.*** No construction would ever be accomplished without owners who must make the decision to build the facility, define the need, provide the financing, and manage the construction process. Owners are public (government) or private. Most public owners such as the **Corps** of Engineers or State Departments of Transportation are experienced construction managers. Most private owners, such as small manufacturing companies, have little or no construction management expertise and depend on consultants to help them through their project, besides providing the project funding; the primary responsibility of the owner is to define the scope of the work.

***General Contractors.*** Most contracts are awarded to a **general contractor** (GC) who manages the project, and subcontracts portions of the work, such as the electrical and mechanical work, to subcontractors or specialty contractors. The primary job of the general contractor is to manage the job, keep it on schedule, control costs, and ensure the work is well coordinated and performed in a safe manner, and to coordinate with the owner on all matters since the GC is the only one of the contractors holding a contract with the owner.

***Subcontractors or Specialty Contractors.*** These contractors make up the largest portion of the construction industry. They do the work. All subcontractors have a specialty such as electrical or mechanical, steel **erection**, **acoustical**, **drywall** and painting, and **carpeting**. The construction of a typical building may require as many as 10 to 15 subcontractors.

***Designers—Architects and Engineers.*** Project owners select an architect or engineer (A/E) to design their projects. The owner should select the A/E based on demonstrated ability to design the

project, in the time frame available, and at a cost acceptable to the owner. The designer will prepare the construction documents for the project owner. Architects are the lead designers for buildings. They subcontract some of the work such as the structural frame and mechanical systems, to engineers who specialize in such work. Engineers are normally the lead designers for heavy civil and highway projects. They may subcontract part of the work such as train stations or office buildings to an architect.

***Construction Managers.*** During the 1970s the term construction manager became popular. Unfortunately today “construction manager” has many different meanings. Some contractors now call themselves construction managers. Usually they subcontract 100% of the project work and prefer to be involved in both the design and construction processes. They bring construction expertise to the design process. Some engineering and architectural firms offer construction management services, indicating usually that they represent the owner during construction. To make the definition even more difficult, there are some government agencies that have employees who are construction managers. Not all people who call themselves construction managers work for a construction contractor.

***Insurance Companies.*** Contractors are required to provide bid bonds as a condition of being allowed to bid, and then they must provide insurance, performance bonds, and payment bonds prior to award of the contract. Insurance companies provide bid bonds, performance and payment bonds, and they also service the liability and property insurance needs of contractors.

***Banks.*** Banks provide the **working capital** contractors need to build the project. In some countries, a payment is made to the contractor at the time of the contract award to provide working capital. In the United States, contractors must earn their **progress payments**, and no **up-front payments** are made. Banks provide the working capital.

***Suppliers.*** Everything from concrete to paint comes from suppliers. Many suppliers assist the contractors in preparing their bids. Preparing **shop drawings**, and fabricating items specifically for **individual projects**. The quality of a construction project is very dependent on the quality of the suppliers used by individual contractors. Designers rely heavily on standard specifications and standards such as those published by the American Society for Testing and Materials (ASTM). It is most important that designers understand the standard specifications and **design standards** they are using because there are design standards for nearly every level of product quality. When the owner wants a high-quality product, it is important to use a high-quality standard.



## Words and Phrases

en-suite 套房
gold-plated 镀金的
general contractor 总包商
construction manager 施工经理
compromise ['kɔmprəmaiz] *n.* 妥协，折中方法
trimmed [trimd] *adj.* 平衡的；纵倾的
budget ['bʌdʒit] *n.* 预算；经费
reliability [riˌlaiə'biliti] *n.* 可靠性

interrelate [ˌintəriˈleit] *vt.&vi.* 相互关联
irreplaceable [ˌiriˈpleisəbl] *adj.* 不能调换的，不能代替的
marble [ˈmɑːbl] *n.* 大理石
residential [ˌreziˈdenʃəl] *adj.* 住宅的，与居住有关的
erection [iˈrekʃən] *n.* 建立，建造，竖立物，建筑物
acoustical [əˈkuːstik(ə)l] *adj.* 听觉的，声学的
block [blɔk] *n.* 街区，街段，大块(木料、石料、金属等)
paramount [ˈpærəmaunt] *adj.* 最高的，首要的，主要的
outpatient [ˈautˌpeiʃənt] *n.* 门诊病人
trim [trim] *vt.* 除去，削减
carpeting [ˈkɑːpitiŋ] *n.*毛毯，地毡毛毯
owner [ˈəunə] *n.* 业主，所有人
corps [kɔː] *n.* 军团，特种部队
acoustical [əˈkuːstik(ə)l] *adj.* 听觉的，声学的
drywall [ˌdraiˈuwɔːl] *n.* 清水墙
capital [ˈkæpitl] *n.* 资本，资金
working capital *n.* 流动资金
specification [ˌspesifiˈkeiʃən] *n.* 规范，说明书
concrete [ˈkɔnkriːt] *n.* 混凝土
shop drawing 制造图，施工图
design standard 设计标准
up-front payment 预付款
progress payment 进度款
individual project 单项工程

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Few make their products in the open air, ________ their manufacturing methods to the climate and season.
2. When actual costs ________ their budgets the contractor’s profits are at risk.
3. The project should meet all specifications in respect of ________, ________, ________ and ________.
4. Some ________ and ________ firms offer construction management services, ________ usually that they represent the owner during construction.
5. In the United States, contractors must earn their ________ payments, and no ________ payments are made.

Ⅱ. Translate the following passages from English into Chinese.

There has been a marked decline in the use of traditional (design-tender-build) procurement, slow growth of management methods and slight growth (with major fluctuations) of design and build methods. Sub-contraction has become almost universal so, irrespective of the procurement

method adopted, the main contractor acts as construction manager only.

Procurement methods will move towards contractor-led systems. Design and build methods will increase in use to treble in importance by 2001. Management methods will be employed for large projects, maintaining their market share. The traditional system will remain important, particularly for smaller and refurbishment projects.

## Section C Construction Quality Management

### Introduction

Quality management has seen a transition from reacting to the outcome of site production activities to becoming a strategic business function accounting for the **raison d'etre** of construction companies. Unless a construction company can guarantee its clients a quality product, it can now no longer compete effectively in the modern construction market. Crucial to the delivery of such quality products is the quality of processes that produce the product. 'Quality' now stands alongside 'price' as a major factor of **differentiation** in contractor selection by the client as well as determining the efficiency of processes that the contractor adopts for site operations. To be competitive and to sustain good business prospects, construction companies need a more strategic **orientation** for the quality systems they **deploy**.

Quality has received much attention in construction since the 1990s, or even earlier. Many government departments have made it mandatory for contracting firms to have their quality system **accredited**. ISO 9000 is the international standard accepted for certification of quality management systems (QMS). While some large contractors are enjoying benefits from implementing their QMS, the smaller firms report difficulties and obstacles.

### Quality Management Systems Adopted by Construction

According to ISO 9000:2000, a system is a set of interrelated or interacting elements. A system can include different management systems such as a financial management system, an environmental management system and quality management system. For an organization, a quality management system is a management system to direct and control an organization with regard to quality. A construction contractor usually has three quality documents for running a quality management system. The three quality documents are as follows.

### Quality Manual

This is a company-wide document setting out the general quality policies, procedures and practices of the organization. A quality manual usually comprises the following:

1) Company policy statement which includes a statement, a summary of activities undertaken and the firm's policy objectives towards implementing a quality system in accordance with the requirements of a standard.

2) General statement to amplify the company's commitment to implementing a quality system.

3) Amendment re-issue and distribution.
4) Authority and responsibility included in the firm's organization.
5) Summary of different procedures.

## Quality Procedures

These are documents describing the activities involved in conducting business which are essential to the achievement of quality, e.g. instructions for the production of concrete would require a quality procedure. They are in fact method statements which make reference to relevant specification documents.

The quality procedures include the following:

- Scope and purpose of the procedures.
- Sequence of actions.
- Persons responsible in the execution of duties and for ensuring that requirements are met.
- Remedial actions if non-conformance is detected.

In preparing the quality procedures, the construction firm should already have a number of in-house procedures in controlling its work. Therefore, a **substantial** part of the preparation of the quality documents entails collecting, documenting and systematizing existing procedures, instructions and practices. The quality documents should be based on the existing practices as long as they are in compliance with the established policies.

## Quality Plan

Besides the quality manual and the quality procedures, which are applicable to the entire company, there is also a quality plan which is applicable only to a particular project (or a construction contract) undertaken by the company. Therefore, there can be a number of quality plans for a company, depending on the number of individual projects it is undertaking.

A quality plan is the document derived from the quality system setting out the specific quality practices, resources and activities relevant to a particular contract or project. Normally a quality plan comprises an organization's quality manual, the relevant standard quality procedures and any additional specific quality procedures.

## Quality Control (QC) and Quality Assurance (QA)

Quality control (QC) is the specific **implementation** of a quality assurance (QA) programme and related activities. Effective QC reduces the possibility of changes, mistakes and omissions, which in turn result in fewer conflicts and disputes.

Quality assurance (QA) is a programme covering activities necessary to provide quality in the work to meet the product/project requirements. QA involves establishing project related policies, procedures, standards, training, **guidelines**, and system necessary to produce quality. QA provides protection against quality problems through early warnings of trouble ahead. Such early warnings play an important role in the prevention of both internal and external problems.

Quality assurance emphasizes defect prevention, unlike quality control, which focuses on

defect detection once the item is produced or constructed. Quality assurance concentrates on the production or construction management methods and procedural approaches to ensure that quality is built into the production system. Quality assurance involves planned and systematic actions necessary both to provide adequate confidence that a product or service will satisfy given requirements or standards and to be able to demonstrate any such compliance to that quality standard.

## Quality Control Implemented in Construction

Traditionally there are two sets of documents that are used to determine the required quality of a construction project. These are the Specifications and the **Contract drawings**. The contractor uses these two documents during the site operations stage of any project to facilitate 'quality' construction.

The process of actual construction is dissimilar to that of a production line in that there are no fixed physical and time boundaries between each operation of the process; hence the positioning and timing of quality inspection cannot be predetermined. In construction quality checks are undertaken as each operation or sub-operation is completed. The majority of quality checks are undertaken visually. Visual quality checks of each section of construction are undertaken by the contractors' engineers and foremen and then by the resident engineers and inspectors to ensure that it comply with the drawings and specification. Quantifiable quality checks are also made during the construction stage. These include testing the strength of concrete cubes, checking alignment of **brickwork** and commissioning of services installations. The results of these quality checks are recorded and passed to the resident engineer.

The weakness of quality control is the development of the inspection mentality or culture, whereby, the construction contractors' operatives and engineers set their standards to that which they can 'get past the inspector'. In addition to potentially **surrendering** the standards of workmanship to an inspector, it exposes the contractor to expensive re-work if the standards of workmanship obtained do not meet with the inspector's approval. It would be much better if the contractors' engineers and operatives had a clear understanding of the quality required, were able to recognize it themselves and achieve it first time or regulate it by self-inspection. This concept, which is the basis of quality assurance, potentially reduces the risks of producing unsatisfactory work and becoming involved in expensive re-work. Notwithstanding the existence of quality assurance and the emergence of total quality management most clients still engage inspectors through their resident engineers or architects to reassure themselves. However, the impact and importance of the clients' inspectors is much reduced in a quality assured or total quality managed company.

## TQM

**Total Quality Management (TQM)** is a process led by senior management to obtain the involvement of all employees in the continuous improvement of the performance of all activities, as part of normal business, and to meet the needs and satisfaction of the customer whether internal or external. Also, TQM is the integration of all functions and processes within an organization in order to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction and continuous improvement.

The concept of customer satisfaction goes far beyond the traditional idea of providing an

acceptable product to the owner for whom we are working. The "customers" are considered to be everyone involved in the building process from designers to subcontractors and employees. With the goal of developing an **atmosphere** of pride, trust, and **profitability** in the construction process, the TQM concept does away with traditional **hierarchical** barriers and encourages **innovation** and cooperation. Ideas flow more freely, and decisions are made with more input from all of the parties involved.

Continuous improvement means making every job better than the last one. Ask "is there a better way to perform this task?" if so, learn from the experience and share it with other members of the project team. This attitude of continuously doing a better job can be seen at every level in the TQM construction company—from the laborers on the job site to the upper levels of management. TQM is a philosophy, not a planning. Successful implementation requires a change in attitude as well as changes in the way we do business.

## Words and Phrases

raison d'etre [ˌreiˈznˈdetrə] *n.* 存在的目的或理由
differentiation [ˌdifərenʃiˈeiʃən] *n.* 区别；分化
orientation [ˌɔːrienˈteiʃən] *n.* 方向，目标
deploy [diˈplɔi] *vt.* 施展，部署
mandatory [ˈmændətəri] *adj.* 命令的，强制的，义务的
accredited [əˈkreditid] *adj.* 可接受的，可信任的，质量合格的
substantial [səbˈstænʃəl] *adj.* 坚固的，结实的，大量的，重大的
implementation [ˌimplimenˈteiʃən] *n.* 执行
guideline [ˈgaidlain] *n.* 指导方针，准则
contract drawing 图纸
brickwork [ˈbrikwəːk] *n.* 砌砖
surrender [səˈrendə] *vt.* 放弃，抛弃
TQM *abbr.* total quality management 全面质量管理
atmosphere [ˈætməsfiə] *n.* 气氛，环境
profitability [ˌprɔfitəˈbiliti] *n.* 收益性
hierarchical [ˌhaiəˈrɑːkikəl] *adj.* 分等级的
innovation [ˌinəuˈveiʃən] *n.* 改革，创新，新观念

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Crucial to the ________ of such quality products is the quality of processes that produce the product.

2. Many government departments have made it ________ for contracting firms to have their quality system ________.

3. This is a company-wide document setting out the general quality ________, ________ and ________ of the organization.

4. Effective QC reduces the possibility of ________, ________ and ________, which in turn result in fewer ________ and ________.

5. TQM is a ________, not a planning.

Ⅱ. Translate the following passages from English into Chinese.

Traditional quality control is the practical implementation of techniques to ensure the quality of work is satisfactory. There are no standard methods for implementing quality control techniques; hence it is unlikely that there is a consistency of quality between companies claiming to use quality control. The variability of quality control results in the loss of the competitive edge that it potentially affords a company in the marketplace, because customers cannot quantify the effectiveness of quality control in any one company. QA was created to remedy this situation.

Quality assurance emphasizes defect prevention, unlike quality control, which focuses on defect detection once the item is produced or constructed. Quality assurance concentrates on the production or construction management methods and procedural approaches to ensure that quality is built into the production system. The ultimate objective of QA is to provide the client with the quality of work required without the need for clients to check during the process.

# 参 考 译 文

## 第 16 章　管理在土木工程中的作用

### Section A　工程安全管理

**建筑业**

在很多国家，建筑业都是国民经济的重要组成部分。然而据统计建筑业在很多国家和地区都是最危险的行业之一。通常，建筑业被认为是危险的、脏乱的、艰苦的和不安全的行业。例如，在 1999—2001 年之间，台湾省所有行业中大约 60%的死亡事故发生在建筑业。随着中国建筑业的快速增长，建筑安全已经成为一个焦点，因为建筑工人的伤亡引起了巨大的损失。在 2004 年，中国建筑业的从业人员数量是 2558 万人(2005 中国国家统计局)。而且近 5 年来，每年平均有 1300 名建筑工人死于建筑安全事故。

全球范围内建筑业的死亡率揭示了一个固有地较差安全风险管理文化。在 1986—1992 年之间的每一年，与其他所有行业每 100 000 名工人平均死亡 2 人相比，英国建筑业每 100 000 名建筑工人中平均有 10 人死亡。

现代工业具有规模化、高度自动化和复杂化的特征。程序和流程是相互联系，相互影响，相互制约的。一旦发生事故，将会对工人的生命和健康产生重要影响，而且也会对生产设备造成严重的破坏。施工现场安全对于建筑公司具有极大的重要性，除了引起工人受伤外，建筑事故也会延误工程进度，增加成本，民事赔偿，以及破坏承包商的声誉。

施工过程包含着危险的作业活动，比如，高处施工，手工操作，危险物料的暴露，爆破，框架搭设，起重操作，脚手架搭设和土方工程。建筑业倾向于“经济繁荣与萧条的交替循环”周期，生产不足和生产力过剩，间断施工以及气候影响。建筑业的这些负面特征的结果包括不必要的财务和人员损失。

**事故的成本**

所有的事故都会影响利润底线。事故是导致产品损失，疾病或伤害，设备或财产的毁坏，

接近失败的那些事件。事故不能被简单地用工人的补偿成本来测量。这些事故破坏了施工现场的连续性，引起时间损失，酬金损失，班组的破坏，或者关键人员的丧生，以机器和设备毁坏形式的财产损失，以及在事故调查期间监理人员时间损失或者职业安全与卫生管理局的调查/检查导致引证和干扰的成本，以及法律事务和费用的成本。同时，保险费以及工人的补偿率将会增加。同时还有毁坏的财产、新规程、新设备、劳动纠纷和承包商的宝贵时间的成本。

可以看出，事故的成本不是完全可测量的，但是成本内容非常清楚。这些成本对施工工序的效率和有效性产生很大的影响，但是通常在施工现场通过对安全和健康给以更多的关注来避免。

**安全计划**

越来越多的公司开始认识到制定并实施一个有条理的、深思熟虑的安全计划的必要性。不但一个雇主有法律和道德责任提供一个安全的工作环境，而且安全也会产生经济效益。由于事故引起的工作日减少会造成一个工作班组分工的混乱而且会降低施工班组的效率。商业责任保险和职工赔偿保险费率的上涨是建筑业伤亡倾向，以及个体公司的良好或拙劣事故记录的生动写照。

一份有效的安全计划要求高级管理层在制定安全计划之后全心全意地执行，而且当访问施工现场时，戴安全帽、防护眼镜，或者任何其他指定的安全设备。只有那样建筑工人才会看到，管理人员是严格遵守安全计划的。一份基本的安全计划由以下部分组成：

- 安全计划的组织；
- 计划的执行；
- 培训及安全会议；
- 应急预案；
- 事故报告的有关要求；
- 工作安全标准；
- 防火措施。

**人员培训**

构成安全规程的技能必须经过学习，而且为了安全措施及其实施，给一个经过很少或没有经过安全技术培训的工作负责人分配责任是不公平的。如果他们没有完全理解如何处理权利与责任的关系，很少会有人全心全意地参与此类计划。

可以通过以下几种方式完成培训。在每一个施工现场举行安全讨论会，或者把所有计划管理人员集中在一个地点进行学习。保险公司通常最希望指导，或者至少参与这些培训。

**安全会议**

为了有效实施安全计划，人们不得不总是想起有利的安全措施，而且他们必须知道工作和公司事故记录。一种提高意识的方法是在施工现场定期召开安全会议。这些会议被称为“工具箱会议”，可以由任何一名管理人员或者项目经理来组织实施。这些会议应该在工作时间举行，而且应该让所有上班的职员参加。有必要得到每一个分包商的允许，让他的工人也参加这些会议。

在最初的会议上，应该概述安全会议的目的和目标，解释安全计划，确定安全措施的基础原则。

**安全文化**

安全文化渗透到整个工程组织是形成安全工作的重要因素。安全文化是个人价值与集体价值，态度、观念、能力以及行为方式的融合，它决定了一个组织安全管理的投入、风格和

效率。简言之，安全文化是一个组织的成员共享安全信念的精华。文化不能被制造和移植，它需要慢慢地形成，需要时间才能生根。回报是公司的职员不仅遵守安全规则和规程，而且安全工作需求内在化。安全文化的特征有：

- ◆ 公司高层对安全工作的领导和投入是真实可见的；
- ◆ 有一个长期的策略；
- ◆ 必定有一项期望值较高的政策可以传达乐观主义精神，这种乐观主义讲述“什么是可能的”并由适当的程序支撑；
- ◆ 安全标准“主人”感，广泛深入的安全政策和培训投入；
- ◆ 设定了安全表现目标，定期地测量并将实际表现与设定的目标进行对比；
- ◆ 良好的安全行为是持续雇佣的条件，并且在每年的考核中予以考虑；
- ◆ 包括安全评价和商业信息在内的管理信息系统。

通过这种方式，建筑公司可以形成一种安全文化——它是在组织内改善安全氛围的一种有效、富有弹性、省力的方式。安全经理是形成浓郁安全文化的重要推动者。

**安全评价**

安全评价，也被称为风险评估，旨在通过系统安全工程原则及方法识别和分析存在于系统中的风险因素，其目标是实现系统安全的目的。它能确定系统中事故以及职业病的概率和严重性，为事故预防决策与管理提供了科学依据。

安全预评估是安全评估的一种，用于分析和预测存在于工程项目中危险的风险，以及为基于工程项目可行性研究报告的安全技术和安全管理提供合理和实用的建议。实际上，它是一种在工程项目早期阶段通过运用安全评价的原则和方法分析项目危险的预测性评估。工程项目安全预评估对于实现“安全第一，预防为主”的方针是一种非常重要的技术支持，同时也是一种安全生产监督和管理的主要方式。

安全预评估的核心是对系统中的风险因素进行定性或定量分析。换言之，根据特定系统范围评估事故和危险的发生概率和严重性。关于主要的危险因素及其后果，安全预评估能提供预防和减轻对策，而且在采取这些措施后可以评估系统能否满足相关的政府法律和规章的安全要求。因此，结论是如何设计和管理工程项目以满足安全需求。



## Section B 工程管理

**概述**

项目最基本的定义是一些具有起点，具有产出的中间阶段和结束阶段并且能创造出新事物的人类活动形式。在建筑业中，项目可以创造出一座建筑物或一项土木工程产品。定义是很重要的，因为它强调施工过程的短暂性——建筑公司到达现场，进行建设，竣工并开始下一个新的项目。项目现场可能会远离建筑公司的总部，而且对于一些大型的国际工程项目，它位于其他国家，在不同于建筑公司本国社会的、经济的和自然环境中实施工程。不像其他工业会为每一种产品在每一个新的地方建造一座新的工厂，很少在露天环境下生产产品，针对气候和季节调整他们的生产方法。

为了实现特定的目标，工程管理需要对施工工作或工序进行计划、进度安排、评估和控制，在一定程度上，通过有效分配和利用适当的劳动力、材料和时间资源来最小化成本，最大化顾客/业主的满意程度。

**项目管理的目标**

图 16.1 揭示了所有业主向建筑公司所要求的东西：即按时，在预算范围内，规定的技术

性能和质量标准完成项目。实现所有这三个目标，业主是非常费力的，也会越来越多的不情愿地接受“管理折中”，这是最近以来的常见做法。质量是一个特别重要的条件。如果建筑承包商不能有效地管理项目，他们可唯一使用的“折中方案”会花费他们自己更多的钱去完成其余两个目标。

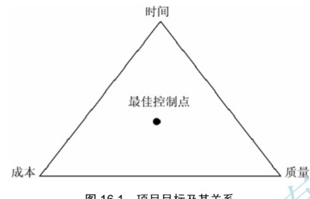



图 16.1　项目目标及其关系

**1) 预算**。所有的工作应该以预算为标准来实施。对于一个小型的建造商，就是通过他们估算的劳动力和材料成本完成一系列规定的工作。对于大型项目，都是由一些比较大的承包公司来建造，预算不仅包括这些工作，也包括每一个与此有关的总公司部门，以及项目的其他组成部分及相应的机构。当实际的成本超过预算时，承包商的利润就处于危险的边缘。如果损失非常大的话，承包商的业务会处于危险之中。甚至不得不放弃项目，或者重新雇佣一个承包商。

**2) 时间**。时间通常是所有目标中最重要的目标。时间是一项不可代替的资源。如果一项工作滞后，那么意味着已经错过它的目标日期，不幸的是，时间不可倒流。成本随着时间而来，且随着时间的增加成本也在不断增加。一个项目如果竣工日期延长的话，通常同时带来的是预算的超支。因此，控制进度计划有助于控制项目的成本。

**3) 质量**。项目应该满足所有关于外观、安全、可靠性、性能方面的技术规范要求。

**4) 平衡三大主要目标**。三大主要目标之间是互相联系的。例如，通常时间与成本相关。项目业主有时必须决定，无论给予其中哪一个目标更多的关注，也许会损失另外两个目标。

在这篇文章中，质量是一个特别的词。通常，能被人们广为接受的质量的定义是：实体必须符合它的预期目的。当然，每一个项目都必须符合它的预期目的。因此，“质量”是这样一个目标，它不可以协商，因为它是一个绝对条件，而且不能用于平衡其他目标。

然而，考虑两个不同的施工计划，每一个都是大型的住宅公寓。其中一个是奢华的小区，开发商希望从富有的租客那里获得较高的租金。另一个是当地的官方项目，为了给低收入或没有生活来源的家庭提供基本的居住条件。这些开发中的一部分全部建在风景区，都有带浴室的套房，并且有镀金的家具，大理石地板，每套公寓都有两个车库。或许裸露的混凝土是当地的官方建筑一个主要特征。但是这些项目中的每一个都有其不同的目的，当竣工时，如果它符合其预期的目的，可以被叫做满足质量条件。

下面是一些平衡决策的例子：

(1) 一座核电站首要的是可靠和安全。因此质量目标是最重要的。

(2) 一个奥林匹克运动会体育场项目必须能及时为比赛做好准备。因此时间是最重要的目标。

(3) 一个医院管理团队需要为门诊病人建设一定面积的诊疗室和候诊区。但是预算非常有

限，因此，必须降低规格以便成本尽可能的低。

项目参与方

**业主**。在任何时候，工程的实施必须有业主参与，他必须为建设设施定义需求、提供资金以及管理施工过程做出决策。业主可以是公共部门(政府)或者是私人部门。多数公共部门业主，例如，工兵部队或者政府交通部门都是富有经验的工程管理者。多数私人部门业主，例如，小型制造企业在整个项目实施过程中拥有很少或者没有工程管理技能，他们依靠咨询顾问帮助，除了提供项目资金外，业主的首要责任是定义工作范围。

**总承包商**。大多数合同授予总承包商(GC)去管理项目，工程的部分分包给分包商或者专业承包商，比如电气工程和机械工程。总包商的首要工作是管理工程，保持工程按照进度安排实施，控制成本，确保以一种安全的方式很好地协调和实施工程，在所有的事宜上与业主进行协调，因为总包商是唯一与业主拥有合同关系的承包商。

**分包商和专业承包商**。这些承包商构成了建筑业的最大部分。所有的分包商都拥有一项专长，比如电气或者机械安装工程，钢结构安装，声学工程，清水墙砌筑和油漆，地毯。一个典型的建筑物的建设需要 10～15 个分包商。

**设计师——建筑师和工程师**。项目业主选择一名建筑师或工程师(A/E)去设计项目。业主应该根据设计实力选择 A/E，在允许的时间内，以业主接受的成本设计项目。设计师为项目业主编制施工文件。建筑师是建筑物的主要设计人员。他们把工程的一部分分包给在某类工程方面具有专长的工程师，例如，结构框架和机械系统。工程师通常是大型土木工程和高速公路项目的主要设计人员。对于建筑师，他们分包工程中的一部分，比如火车站或者办公楼。

**施工经理**。在 20 世纪 70 年代，施工经理这个称谓开始流行起来。不幸的是，今天“施工经理”有许多不同的含义。现在一些承包商把他们自己称为施工经理。通常，他们分包工程项目的 100%，而且更喜欢同时参与设计和施工过程。他们把施工知识引入设计过程中。一些工程公司和建筑公司提供工程管理服务，通常认为他们在施工过程中代表业主。为施工经理下个定义很困难，有一些政府代理公司雇佣施工经理。所有称呼他们自己为施工经理的人不都是为施工承包商工作的。

**保险公司**。承包商被要求提供投标保证作为允许其投标的一个条件，然后他们必须在授予合同之前提供保险、履约保证和支付保证。保险公司提供投标保函、履约和支付保函，而且他们也向承包商提供贷款和财产保险服务。

**银行**。银行为承包商提供项目建设所需要的流动资金。在发包时，一些国家规定需要为承包商支付一笔工程款作为流动资金。在美国，承包商必须取得他们的进度款，而且没有预付工程款。银行提供流动资金。

**供应商**。所有一切，从混凝土到涂料都来自于供应商。许多供应商协助承包商编制投标文件。编制施工图，以及为单项工程加工所需构配件。工程项目的质量非常依赖于具体承包商所雇佣的供应商的质量。设计师严重地依赖标准技术规范和设计标准，比如由美国试验与材料协会出版的标准和规范。最重要的是设计师要理解他们所使用的标准技术规范和设计标准，因为对于每一个产品质量等级几乎都有对应的设计标准。当业主要求一个高质量的产品时，重要的是必须要使用高质量产品等级的标准。

## Section C 工程质量管理

概述

质量管理已经见证了从现场生产活动成果的评价到担当解释建筑公司存在理由的战略商

业功能的转变。如果建筑公司不能保证提供给业主质量合格的产品的话，建筑公司在现代建筑市场中的竞争力就不明显了。对这些质量合格的产品的采购至关重要的是生产产品过程的质量。如今，“质量”与“价格”一样是业主选择承包商的一项主要判别因素，同时，决定了承包商现场操作过程的效率。为了竞争和维持良好的商业前景，建筑公司需要建立一个更多以战略为导向的质量系统。

自从 20 世纪 90 年代开始或者更早，建筑业已经对质量给予了许多关注。许多政府部门已经强制承包公司拥有公认的质量系统。对于质量管理系统的认证，ISO 9000 是广为接受的国际标准。同时一些大型承包商正在从他们实施的质量管理系统中获益，小型公司则报告它们在实施质量管理系统中遇到的困难和障碍。

**建筑业采用的质量管理系统**

根据 ISO 9000：2000，系统是一组相互关联或者相互作用的要素的集合。一个系统包括不同的管理系统，例如金融管理系统，环境管理系统以及质量管理系统。对于一个组织而言，质量管理系统是一个组织指导和控制质量的管理系统。通常，为了运行一个质量管理系统建筑承包商需要建立三个质量文件。这三个质量文件如下：

**质量手册**

质量手册是一个公司范围内规定公司总的质量方针、规程和惯例的文件。质量手册通常由以下部分组成：

1) 公司政策陈述，包括陈述，承担工作的总结以及根据一项标准的要求，公司实施质量体系的政策目标。

2) 增强公司执行质量系统投入的综述。

3) 重新修正和分配。

4) 公司内部机构的权利和责任。

5) 不同规程的概述。

**质量规程**

它是在指导业务时描述复杂活动的文件，是达到质量要求必不可少的条件，例如，混凝土生产操作指南要求一个质量规程。事实上，它们是参考有关规范文件做出的方法描述。

质量规程包括以下内容：

- 规程的范围和目的。
- 措施排序。
- 履行义务过程中的责任人以及确保满足规定。
- 如果发现不一致，修改措施。

在编制质量规程时，建筑公司应该已经拥有大量的控制其工作方面的内部规程。因此，质量文件编制的重要组成部分是收集、记录和系统化现行规程、操作指南和惯例。质量文件应该是建立在现行惯例基础上的，只要它们与已制定的方针相一致。

**质量计划**

除了质量手册和质量规程适用于整个公司之外，质量计划仅仅适用于由公司承揽的具体项目(或施工合同)。因此，一个公司有许多质量计划，这依赖于公司承揽的具体项目的数量。

质量计划是来源于质量系统的文件，规定了特定的质量惯例以及一个具体合同或项目所需要的有关资源和活动。通常，质量计划是由一个组织的质量手册，有关的标准质量规程和任何附加的特定质量规程组成的。

**质量控制与质量保证**

质量控制是一个质量保证程序及其相关活动的具体实现。有效的质量控制可以减少变化、错误和遗漏的可能性，随之引起更少的冲突和争端。

质量保证是规定所有必须实施的活动的质量满足产品/项目需求的规划。质量保证包括制定项目有关的政策、规程、标准、培训、指导方针以及生产质量所需的体系。质量保证提供了通过提前危险预警防止产生质量问题的方式。这样的预警对于防止内部和外部问题的出现起着重要的作用。

质量保证与质量控制不同，它强调缺陷预防，一旦项目处于生产或者建设过程中它关注于缺陷发现。质量保证专注于生产或者施工管理方法以及程序上的方法，以确保质量在生产系统中形成。质量保证包括根据计划的和必需的系统措施，既可以提供足够的信心使产品或服务符合规定的条件或标准，又能证明所有这些满足质量标准。

**施工质量控制方法**

传统上，用于确定施工项目的质量要求有两个文件，即规范和图纸。承包商在任何项目的现场施工阶段使用这两个文件以保证施工质量。

实际的施工过程与流水生产作业是不同的，因为施工过程中每一项操作都没有固定的物理和时间界限。因此，不能预先确定质量检查的地点和时机。施工中质量检查是在每道工序或子工序完成后进行的。大多数的质量检查是外观检查。每个施工段的外观质量检查是由承包商的工程师和工长来完成的，然后由驻地工程师和监理工程师确定其是否符合图纸和规范的要求。在施工阶段也要进行可量化的质量检查。其中包括测试混凝土试块的强度，检查砌砖的水平度，以及配套设施的试运转。这些质量检查的结果将被记录并呈递给驻地工程师。

质量控制的缺点在于随着检查思想或文化的发展，由此使施工承包商的工人和工程师将他们的工作标准仅设定为能“对付监理工程师的检查”。另外工艺的标准将隐含地由监理工程师决定，如果检查得到的工艺标准没有得到监理工程师的认可，承包商要付出昂贵的返工费用。如果承包商的工程师和技工对工程质量要求有清楚的理解，他们就能通过自检一次性完成工作或及时调整工序。这种以质量保证为基础的思想能降低潜在的产生不合格工程和陷入昂贵的返工成本的风险。尽管质量保证的存在和全面质量管理出现，大部分的业主仍然雇佣监理工程师，通过他们的驻地工程师或者建筑师从事检查工作。然而，业主的监理工程师的影响和重要性在获得质量保证或者实行全面质量管理的公司已大大减弱。

**全面质量管理**

作为常规业务的一部分，全面质量管理(TQM)是一个由高层管理人员领导，要求全员参与所有活动性能的持续改进，实现内部或外部客户需求和满意的过程。同时，为了完成产品和服务质量的持续改进，全面质量管理是组织内所有功能和过程的整合。其目标是顾客满意和持续改进。

顾客满意的概念已经超出了为业主提供一个令人满意的产品的传统观念。这个“顾客”可以是参与建设过程每一个人，包括设计师、分包商以及雇员。随着施工过程中尊重、信任和获利氛围目标的构建，全面质量管理思想消灭了传统的等级障碍，鼓励革新和合作。想法表达更加自由，由所有的参与方共同做出决策。

持续改进意味着使每一项工作都优于上一项工作。问一个“有没有一种更好的途径实现这项工作”问题，如果有答案的话，就是学习经验并且与项目团队的其他成员分享。这种持续做好工作的态度可以被认为在实施全面质量管理的建筑公司每一个层次——从施工现场的工人到更高层次的管理人员都应具有的。全面质量管理是一种指导思想，而不是一种具体的计划。成功的实施全面质量管理要求转变态度以及经营方式。

# Grammar：科技论文的写作(III)——摘要与关键词

## Knowledge on Writing a Research Paper III—Abstract and Keywords

摘要(abstract)是一篇科技论文的核心体现，是一段准确代表论文内容、且对论文内容不加注释和评论的简短陈述。它直接影响读者对论文的第一印象，影响到论文被引用的程度。一篇学术价值较高的论文，若摘要撰写得不理想，会使论文价值大打折扣。因此，掌握英文摘要的特点，按照相关标准，如国际标准 ISO214-1976 (E) Documentation-Abstract of Publications and Documentation 编写摘要，是十分重要的。

与摘要有关的英文词语有 Abstract，Summary 与 Synopsis。若严格细分，Abstract 指对论文进行的摘录或提炼；Summary 则有摘要或概要的意思，指由作者再度扼要陈述论文较突出的发现或结论；Synopsis 为概要及大纲之意，指作者对论文全文的概略描述。一般，采用 Abstract 的情况较多，Summary 与 Synopsis 也时常有用。

为便于文献检索，有时需要在论文摘要后面，给出若干关键词(Keywords 或 Key Words)。关键词是科技论文和文献检索的标志，是从题名、摘要、正文中选出的能反映论文主题概念的词或词组。

### 1. 基本特点(The Basic Characters)

摘要具有以下几个特点：

(1) 是对原文的精华提炼和高度概括，简短扼要，引人入胜，所蕴涵的信息量大；

(2) 具有客观性和准确性；

(3) 能使读者理解全文的主要要素，能脱离原文而独立存在；

(4) 为满足上述特点，所编写的摘要应说明研究目的与范围、材料与方法、结果或成果、结论。

由于受篇幅的限制，上述 4 项内容的叙述，需做到言简意赅、语言流畅。

关键词包括主题词和自由词两部分。主题词是专门为文献的标引或检索而从自然语言的主要词汇中挑选出来并规范化的词或词组，自由词则是未规范化的(即还未收入主题词表中的)词或词组。关键词应主要采用主题词，对那些确能反映论文的主题内容但现行的主题词表还来不及收入的词或词组，可以作为自由词列出。一般的主题词可参阅《美国国会图书馆主题词表》(Library of Congress Subject Headings)，土木工程学科的主题词可参阅 ASCE 的 Subject Heading List to the CEDB(土木工程数据库主题词表)。另外，《汉语主题词表》和《中国分类主题词表》也可资参考。



### 2. 形式和内容(The Form and Requirement of Content)

摘要和关键词的基本形式和内容表现在以下几个方面：

(1) 若无特殊的规定，一般摘要位于论文标题和正文之间，但有时也要求接在正文之后。

(2) 对于一般篇幅的论文，摘要的篇幅控制在 80～100 单词左右；对于长篇报告或学位论文，摘要的篇幅控制在 250 个单词左右，一般不超过 500 个单词。

(3) 一般篇幅论文摘要不宜分段，长篇报告或学位论文的摘要可分段，但段落不宜太多。

(4) 摘要的句型少用或不用第一人称，多采用第三人称被动语态，以体现客观性。

(5) 与标题写作相反，摘要需采用完整的句子，不能使用短语；另外，要注意使用一些转

折词连接前后词句，避免行文过于干涩单调。

(6) 注意体现摘要的独立性和完整性，使读者在不参看正文的情况下就能基本了解论文的内容；摘要的观点和结论必须与正文一致，不可把正文没有的内容写入摘要。

(7) 通常摘要采用一个主题句(topic sentence)开头，以阐明论文的主旨，或引出论文的研究对象，或铺垫论文的工作等，避免主题句与论文标题的完全或基本重复。

(8) 一般包括如下内容：为什么从事这项研究？完成了哪些工作?突出的成果；成果的意义。

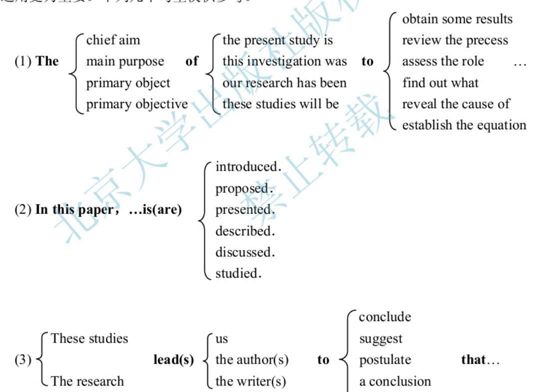
(9) 避免隐晦和模糊的语句，采用准确、简洁的语句概括全文所描述的目的、意义、方法和结论等。

(10) 避免使用大多数人暂时还不熟悉或容易引起误解的单词缩写和符号等；不可避免时，应在这些单词缩写和符号在摘要中第一次出现处加以说明。例如 TM(Technical Manual)、CCES(Chinese Civil Engineering Society)等。

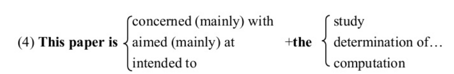
(11) 在摘要之后，通常要附上若干个(3～8 个)表示论文主题内容的关键词、主题词或检索词(indexing term)，应选用规范化的、普遍认可的单词、词组或术语作为关键词，不宜随心编造。一般各词按字母次序或重要性排列，用分号隔开。

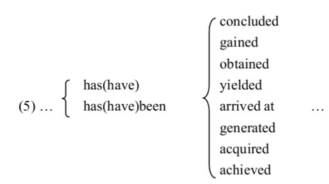
3. 常用句型(Common Patterns)

在撰写摘要时，可套用一些固定句型。不过，掌握句型和词汇特点，并结合实际情况灵活运用更为重要。下列几个句型仅供参考。








【例 1】The proposed approach may be used as a basic for the analysis of distortion-induced stresses in the concrete box girders.

建议的方法可作为分析混凝土箱梁畸变应力的基础。

【例 2】 The main purpose of this paper is to contribute to the development of more rational system reliability-based structural design and evaluation specifications.

本文的主旨为：采用更为合理的系统可靠度理论，促进结构设计和评估规范的发展。

【例 3】 This paper describes the objects, contents, significance and impact of Information Super Highway project being constructed.

本文阐述了建设“信息高速公路”的目标、内容、意义及其影响。

4. 摘要实例(The Example of Abstract)

【例 4】 这是一篇研究结合桥极限荷载的文章摘要，标题是：Ultimate loads of continuous composite bridges(连续结合桥的极限荷载)

**Abstract:** The prediction of the ultimate load capacity of composite bridges of slab-on-I-steel girder construction is necessary. This is dictated by design requirements for the ultimate limit states of such bridges. In this paper, the prediction of the most probable yield-line patterns of failure for relatively wide composite bridges is presented. The prediction is based on a parametric study as well as on laboratory test results on composite bridge models. The degree of fixity between the transverse steel diaphragms and the longitudinal steel girders is considered with respect to influence on the ultimate load capacity of the bridge. Good agreement is shown between the theoretical and experimental results. A method of relating AASHTO truck loading to the collapse load is presented. The derived equations can be used either to predict the ultimate load capacity or the required ultimate moments of resistance for design of simple-span and of continuous-span composite bridges. An illustrated design example is presented.

**Key words**: composite bridges; ultimate load; yield-line pattern

参考译文：

**摘要**：由于设计需求，对混凝土桥面板与工字型钢梁结合的桥跨结构，有必要预测其极限承载力。本文针对相对较宽的结合桥，基于参数研究以及实验室模型试验结果，预测出最可能出现的失效屈服线模式。对钢横隔板与纵向主梁的连接紧固程度以及其桥梁极限承载力的影响也加以考虑。实验结构与理论分析结构很接近。文中提出了一种把 AASHTO 车辆荷载与破坏荷载相关联的方法。所推导的方程可用来预测极限承载力，或用来设计简支或连续结合桥的极限抵抗弯矩。解释见设计实例。

**关键词**：结合桥；极限荷载；屈服时效模式

# Chapter 17

# Construction Planning and Estimating

## Section A Construction Planning and Schedule Management

### Introduction

Planning is the process of considering alternatives and methods to complete a task. Also, planning can be thought of as determining "what" is going to be done, "how," "where," by "whom," and "when." In construction projects the "plans" and specifications for the project generally define both the end product and, often, the general time frame in which to complete the project. Planning creates an orderly sequence of events, defines the principles to be followed in carrying forth the plan, and describes the ultimate disposition of the results. It serves the manager by pointing out the things to be done, their sequence, how long each task should take, and who is responsible for which tasks or actions.

### Construction Planning

Construction planning is a fundamental and challenging activity in the management and execution of construction projects. A good construction plan is the basis for developing the budget and the schedule for work. Developing the construction plan is a critical task in the management of construction, even if the plan is not written or otherwise formally recorded. In addition to these technical aspects of construction planning, it may also be necessary to make organizational decisions about the relationships between project participants and even which organizations to include in a project.

Planning is the starting point of all management functions. Planning leads to organizing and staffing followed by directing, controlling and coordinating. A graphic schedule known as a programme forms the basis for effective planning. The programme should include sufficient details to enable proper consideration to be given to the timing and **duration** of **operations**, type and quantity of materials and equipment, delivery dates and **manpower** requirements.

The essential characteristic of a good programme are:

- It must be suitable for use as a control tool against which progress can be measured;
- It must be sufficiently accurate to enable its use for forecasting requirements of material, manpower, machinery and money;
- It must provide for difficulties likely to be encountered in future in respect of quality, scope, processes etc. and for taking remedial measures.

The goal of planning is to minimize resource expenditures while satisfactorily completing a

given task. Planning aims at producing an efficient use of equipment, materials, and labor, and ensuring coordinated effort. Effective planning requires continually checking on events so that the manager can make forecasts and revise plans to maintain the proper course toward the objective.

## Planning Techniques

The most common and widely used techniques available for planning are **bar charts**, network analysis, either **activity-on-the-node** or **activity-on-the-arrow**.

Bar Charts

Henry L. Grant created a scheduling method by drawing a bar chart, which is the easiest to understand and the most widely used form of planning tool. Activities are represented as bars on the chart, while across the top or bottom of the chart is a time line. For each activity, a bar is drawn from the activity's starting time until its ending time. The bar chart is widely used as a construction-scheduling tool because of its **simplicity**, ease of preparation, graphical format. It is a very useful tool for preliminary planning and scheduling. Bar charts are simple presentations that show how major work activities are scheduled. Its major advantage is that they are easily prepared as time-scaled presentations.

The bar chart is an excellent means of relating activities to time; however, as a planning technique, it has a number of shortcomings. It is particularly when projects become more complex that bar charts begin to fail to provide the type of information that is often so valuable for planning and scheduling. Another disadvantage of bar chart is, although the status of individual activities can be readily **ascertained**, the overall status of a project cannot be determined when some activities are not on schedule. This makes it difficult to assess the need for making scheduling adjustments, and it also makes it difficult to determine the appropriate activities to target for **acceleration**.

Network Analysis

Network analysis is a general term for a graphical planning technique which shows the project as a network of its activities linked together to show their interrelationships and sequence of execution. With the addition of estimates of activity duration, the diagram can be analyzed numerically to determine the estimated project duration. This analysis also **distinguishes** between those activities whose timely execution is vital to the earliest completion of the project, and those which may be delayed for a specific time without causing delay in the project completion. Network analysis offers all the advantages of being able to manipulate the planning data by holding the data in computer files. The planning data in a network is linked through the logic that defines the relationships between the activities. Thus changes can be made in the data relating to individual activities, i.e. the duration, the resources, etc., or changes can be made in the logical relationships between activities and the consequences re-calculated and re-presented.

The steps in producing a network are:

1) Listing the activities;

2) Producing a network showing the logical relationship between activities;

3) Assessing the duration of each activity, producing a schedule, and determining the start and

finish times of each activity and the **float** available;

4) Assessing the resources required.

Network analysis provides

- a diagram in which the work method is made explicit: a logic diagram;
- a means of estimating the project duration by calculation from the activity durations;
- a method of calculation which identifies activities that have a critical effect on the project duration (hence the terms **critical path method** and critical path analysis which are sometimes used to describe this technique);
- a method of calculation which determines by how much non-critical activities may be delayed without causing a delay in project completion.

In practical project management, this last facility of network analysis is most important, because it provides an objective means of scheduling project activities to make the best use of the available resources.

## Advantages of Network Techniques over the Bar Chart

When using network techniques, the interrelationship of all operations is clearly shown. The normal bar chart does not do this, and consequently requires the dependence of one operation on another to be remembered by the planner: this is extremely difficult with large projects, and in addition the site manager has to be informed how dependent one operation is on another.

When a delay occurs, and networks are being used, critical operations will stand out as requiting particular attention. When bar charts are used on a large project many operations tend to be 'crashed' unnecessarily, as it is almost impossible to remember which operations are **interdependent**.

It is far easier for anyone taking over a partially completed project to become familiar with the progress when networks are employed.

When using networks it is essential to study the sequence of operations very carefully, leading to a closer understanding of the project.

Planning, analyzing and scheduling are separated when using networks, which allows a greater concentration on the planning aspect.



## Critical Path Method

The traditional critical path method (CPM) has been widely used in network analysis and project planning ever since 1950s.

Project network techniques cover a number of techniques, one example being the Critical Path Method. The critical path method (CPM) for scheduling is the most widely used scheduling technique. The critical path method (CPM) of **construction scheduling** involves preparing a graphic representation of all of the operations required during the life of a construction project. The critical path method is a powerful tool for the planning and management of all types of projects. Essentially it is the representation of a project plan by a schematic diagram or network that depicts the sequence and interrelation of all the component parts of the project, and the logical analysis and **manipulation** of this network in determining the best overall program of operation. It is a method admirably suited to the construction industry, and it provides a far more useful and precise approach

than the conventional bar charts that previously formed the basis of construction planning and control.

A simplistic explanation of CPM is that each construction activity is shown with an **arrow** diagram. One end of the arrow indicates the start and the other end the completion of the activity. The length of the arrow indicates the length of time **apportioned** to the operation. Some construction operations precede others on a straight-line basis and cannot start until a prior operation has been completed. Other operations can start prior to the completion of the preceding activity, and some operations are performed simultaneously or concurrently with others. This may sound very **elementary**, but it is just this kind of thinking and evaluation that is necessary to construct a CPM network.

All the activities, then, will be displayed by the use of arrow diagrams showing the start and stop times and the duration times. When two or more of the arrows of activities meet, the meeting point is known as an *event*. Activity flows are terminated at events, and **subsequent** operations of phases move forward from one event to another. The events are usually assigned numbers which are used either manually or electronically to change event sequences or durations as the CPM program is monitored during the construction period. Numbering is an easier way to identify events than by using event names. The various activities, arrows, and events used in the CPM schedule make up what is known as the ***network***. A part of network structure sees Fig.17.1.

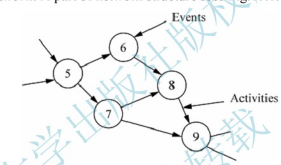



Fig. 17.1 Activity 8-9 cannot start until activities 6-8 and 7-8 are completed



## Words and Phrases

manpower ['mænˌpauə] *n.* 劳动力，人力，体力
bar chart 横道图
construction scheduling 施工进度计划
simplicity [sim'plisiti] *n.* 简单，朴素，率直
distinguish [di'stiŋgwiʃ] *vt.&vi.* 辨别，区别
ascertain [ˌæsə'tein] *vt.* 弄清，确定，查明
interdependent [ˌintədi'pendənt] *adj.* 互相依赖的，互相依存的
float [fləut] *n.* 时差
critical path method 关键线路法
operation [ˌɔpə'reiʃən] *n.* 工序，操作
arrow ['ærəu] *n.* 箭头，箭线
apportion [ə'pɔːʃən] *vt.* 分摊，分配
elementary [ˌeli'mentəri] *adj.* 基本的，初级的，简单的

subsequent [ˈsʌbsikwənt] *adj.* 随后的，继……之后的
manipulation [məˌnipjuˈleiʃən] *n.* 处理，操作，操纵
duration [djuəˈreiʃən] *n.* 持续时间
acceleration [ækˌseləˈreiʃən] *n.* 加速度
activity-on-the-node 单代号网络图
activity-on-the-arrow 双代号网络图

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Planning is the process of considering ________and________ to complete a task.
2. Construction planning is a ________ and ________ activity in the management and ________ of construction projects.
3. Planning leads to organizing and staffing followed by ________, ________ and ________.
4. The most common and widely used techniques available for planning are ________, ________, either ________ or ________.
5. The critical path method is a ________ tool for the planning and management of all types of projects.

Ⅱ. Translate the following passages from English into Chinese.

The contractor's organization is the one of the three parties in the construction process that has historically put greatest effort into the planning process because the results of a well-planned, carefully monitored and controlled contract reflect directly in the profitability of the contract and company. With the benefits of planning clearly visible, it is hardly surprising that the effort is made.

The site manager at the start of the project needs plans or work programmes to determine their resource requirements. During the execution of the project the site manager needs plans to assist in directing those resources, to monitor progress, to evaluate the effect of the changes that may be imposed by varying productivity, by mistakes, by weather or by the client and their designers. In certain forms of contract the site manager needs the project plan to determine payments due at interim stages. At site-manager lever the units of time used for activities are usually weeks or days.



# Section B Construction Estimating and Cost Management

## Introduction

Cost estimating is one of the most important steps in project management. A cost estimate establishes the base line of the project cost at different stages of development of the project. A cost estimate at a given stage of project development represents a prediction provided by the cost engineer or estimator on the basis of available data. An estimate is characterized by the fact that it takes place before the event. It is an attempt to predict the future, so it is at best fraught with hazard and at worst approaching the impossible.

Both owners and constructors need to be informed in advance of the likely costs of construction work. For constructors, successful bidding is critical for survival and this depends to a large extent on estimates of project cost to the constructor. Underestimates, for example, are more likely to win loss-making contracts, while overestimates are likely not to win any contracts at all. Estimates of owner costs are just as important, as underestimates imply cost overrun while overestimates often deny value for money. Cost estimators play an important role in an organization, as they produce most predictions of probable final construction cost. Since both under- and overestimates can be costly, attention should be paid to the estimating tasks.

## The function of the estimate

From an owner's perspective an early estimate helps define the affordability of the construction project, how big the construction project can be for the money available, and what level of quality is possible.

Estimates offer guidelines to the designer, who selects materials and sizes the construction project to fall within the owner's budget. As the construction project proceeds, the design must be continually compared to this budget. If it begins to exceed the budget, the designer must determine the best **alternatives** for cost reduction. Estimating and designing are intimately related.

At the end of the design process estimates must also be prepared by individual trade contractors to figure their bid price. These are done with design documents complete or nearly complete and are the most **time-consuming** and most accurate of the estimates. The project management team often prepares a detailed estimate at this point to verify the accuracy of the bid prices and to negotiate with the trade contractors.



## Types of costs

The cost involved in the construction of a project can be broken down into two major categories: direct and indirect cost.

***Direct costs***. The costs attributed to a single task of construction work are known as direct costs. These costs are usually associated with a construction crew performing a task using specific materials and equipment. Subcontracted costs should be considered direct costs to the prime contractor in estimates.

***Indirect costs***. The costs that cannot be attributed to a single task of construction work are classified as indirect costs. These costs include **overhead**, profit, and bond.

Estimates based on a detailed design will be developed from separate direct cost pricing of labor, materials, supplies, and subcontractors. Applicable indirect costs will be added to reflect the total construction cost. Other pricing considerations, including **escalation**, construction contingencies, and profit, will be added to the construction costs to determine the total project cost.

## Work breakdown structure

**Work breakdown structure** (WBS) development is a technique that supports integrated project business management planning and control. It is a technique that has been used successfully in managing **portfolios**, programs, and projects. The work breakdown structure is at the heart of

project business management (PBM) planning efforts, as it defines the basic project business management structure that provides the framework for development and maintenance of scope, schedule, budget, status data collection, and performance evaluation.

The WBS is a hierarchical breakdown of the scope of work. It provides a common, ordered hierarchy frame word for summarizing information and for quantitative reporting to customers (the client) and management. The purpose of the WBS is to: (1) provide an organized manner of collecting project cost data in a standard format for estimation, cost reporting, and cost tracking; (2) provide a checklist for categorizing costs; and (3) provide a means to maintain historical cost data in a standard format.

## Project cost management

Project cost management involves four processes: (1) Resource planning, (2) Cost estimating, (3) Cost budgeting, (4) Cost control. These processes are designed to provide an estimate of the cost required : l) to complete the project scope, 2) to develop a budget based on availability of funds, management policies, and strategy, and 3) to ensure that the project is completed within the approved budget.

To complete the project activities, different resources are required depending on whether the work is to be done internally or by outside contractors. Labor, equipment, and information, for example, are required for **in-house** activities, whereas money is required for **outsourcing**.

There are various methods of estimating activity costs, from detailed accounting procedures to **guesswork**. Formal accounting procedures can be tedious and time consuming and perhaps a waste of time in case the project is discarded. Thus, early in the project life cycle, rough **order of magnitude** estimates are best, although they are not likely to be accurate.

Estimates of the amount of resources required for each activity, as well as the timing of their use, are based on the activity list and the schedule. Resource **allocation** is performed at the lowest level of the WBS—the work package level—and requirements are rolled up to the project level and then to the organizational level. A comparison of resource requirements and resource availability along with corporate strategies and priorities forms the basis of the allocation decisions at the organizational level. Resource planning results in a detailed plan specifying which resources are required for each work package. By applying the resource cost rates to the resource plan and adding overhead and outsourcing expenses, a cost estimate of the project is developed. This provides a basis for budgeting. As determined by the schedule, cost estimates are time-phased to allow for cash flow analysis. Additional allocations may also be made in the form of, say, a management reserve, to buffer against uncertainty. The resulting budget is the **baseline** for project cost control.

Because of uncertainty, cost control is required to detect **deviations** and to decide how to react to get the project back on track and within budget. Change requests require a similar response. The cost control system is based on performance measures, such as actual cost of activities or deliverables (**milestones**), and actual **cash flows**. Changes to the baseline budget are required whenever a change in the project scope is implemented.

## Types of Construction Cost Estimates

The required levels of accuracy of construction cost estimates vary at different stages of project development, ranging from ball park figures in the early stage to fairly reliable figures for budget control prior to construction. Since design decisions made at the beginning stage of a project life cycle are more **tentative** than those made at a later stage, the cost estimates made at the earlier stage are expected to be less accurate. These are all predictions and should not be considered 100% accurate. The degree of realism and confidence achieved will depend on the level of definition of the work and the extent of the risk and uncertainty. Generally, the accuracy of a cost estimate will reflect the information available at the time of estimation.

Construction cost estimates may be viewed from different perspectives because of different **institutional** requirements. In spite of the many types of cost estimates used at different stages of a project, cost estimates can best be classified into three major categories according to their functions. A construction cost estimate serves one of the three basic functions: design, bid and control. For establishing the financing of a project, either a design estimate or a bid estimate is used.

i. ***Design Estimates.*** For the owner or its designated design professionals, the types of cost estimates encountered run parallel with the planning and design as follows:

- order of magnitude estimates
- **Preliminary** estimates
- Detailed estimates
- Engineer's estimates based on plans and specifications

For each of these different estimates, the amount of design information available typically increases.

ii. ***Bid Estimates.*** For the contractor, a bid estimate submitted to the owner either for competitive bidding or negotiation consists of direct construction cost including field supervision, plus a markup to cover general overhead and profits.

iii. ***Control Estimates.*** For monitoring the project during construction, a control estimate is derived from available information to establish:

- Budget estimate for financing
- Budgeted cost after contracting but prior to construction
- Estimated cost to completion during the progress of construction



## Words and Phrases

alternative [ɔːl'təːnətiv] *adj.* 两者择一的，供替代的
overhead ['əuvəhed] *n.* 企业管理费
escalation [ˌeskə'leiʃən] *n.* 扩大，增加
order of magnitude 数量级
portfolio [pɔːt'fəuljəu] *n.* 公事包，文件夹，投资组合
in-house [in'haus] *adj.* 内部的
outsourcing ['autˌsɔːsiŋ] 资源外取
time-consuming ['taimkənˌsjuːmiŋ] *adj.* 耗时的

guesswork [ˈgeswə:k] *n.* 臆测，猜测
allocation [ˌæləˈkeiʃən] *n.* 配给，分配，拨出
baseline [ˈbeislain] *n.* 基数，底线
direct cost 直接成本
indirect cost 间接成本
cash flows 现金流量
Work Breakdown Structure (WBS)工作分解结构
deviation [ˌdi:viˈeiʃən] *n.* 背离，偏离
milestone [ˈmailstəun] *n.* 里程碑，重要事件，转折点
tentative [ˈtentətiv] *adj.* 试探性的，尝试性的
institutional [ˌinstiˈtju:ʃənəl] *adj.* 习以为常的，公共机构的
preliminary [priˈliminəri] *adj.* 初步的，预备的，开端的

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. An estimate is ________ by the fact that it takes place before the event.
2. Other pricing considerations, including ________, construction ________, and ________, will be added to the construction costs to determine the total project cost.
3. It is a technique that has been used successfully in managing ________, ________, and ________.
4. The WBS is a ________ breakdown of the scope of work.
5. A construction cost estimate serves one of the three basic functions: ________, ________ and ________.

Ⅱ. Translate the following passages from English into Chinese.

The construction industry, unlike many manufacturing situations, is concerned mostly with one-off projects. This naturally creates difficulties for effective management control, because each new contract often has a fresh management team, and sites dispersed throughout the country, which tends to cause problems in effective communications with other parts of the company, and frequent use of subcontractors and temporary labor items, and the ever-changing weather conditions.

To control cost is an obvious objective of most managers, but it should be recognised that no amount of paperwork achieves this control. Ultimately, the decisions of the massager that something should be done differently, and the translation of that decision into practice, are the actions which achieve control. The paperwork can provide guidance on what control actions should be taken and, while we shall continue to call 'the cost control system', it should more properly be called 'the cost information system'.

# Section C Construction Contract Management

## Introduction

Most projects require that many contractors, subcontractors, material suppliers, manufacturers,

and others carry out the functions that traditionally have not been performed by the engineer, architect, or project owner. Whether the project is an electric generating station, **pipeline** system, chemical plant, office building, or manufacturing facility, these organizations perform various activities, undertaken for consideration (money) from the owner, and are assigned various duties and responsibilities as well as fights. These elements are commonly reduced to written form and represent a contract between the owner (buyer) and the contractor (seller).

In construction, it is universal practice for the contract to be formalized in the form of a written document. Its main purpose is to define exactly the rights and **obligations** of each party (i.e. owner, contractor etc.). It describes precisely the legal, financial and technical provisions of the work. It usually contains clauses that specify completion time of the project, **liquidated damages**, particulars concerning payments to the contractor, scope and nature of the work to be done etc. The contract document is signed by both parties (owner and contractor). It is an agreement which is reached by the acceptance of an offer made by one party to do something for the other for a certain consideration. In engineering contracts, the offer usually takes the form of a **proposal** (also called a bid or tender) by a contractor to do the work specified by the owner for a monetary consideration, under certain conditions laid down by the owner. The elements of a contract, therefore, are the offer, monetary consideration and acceptance.

## What is contract

A contract is a legally binding agreement between two or more parties to exchange something of value. In construction, it is usually money in exchange for construction services to build a facility. A contract imposes both contractual and legal obligations on both parties that are difficult or impossible to change. The principal function of enforcing a contract is to encourage economic exchanges that lead to **economic efficiency** and greater **productivity**. Contracts are enforced no matter how **harsh** the terms, provided the contract was freely agreed on. As stated by one court, parties cannot ignore provisions of the agreement to suit their own convenience or profit.

## Contract Types

Just as the owner makes the decision regarding the type of project delivery to be employed, the owner also determines which contract will be utilized for the project. Generally, which form is used depends upon the type of project and the amount of risk that the owner is willing to accept. It is important that the construction manager be familiar with each type. There are three basic types of construction contracts: **lump sum**, cost-plus-fee, and unit cost.

Lump Sum Contracts

Lump sum contracts are the most common type of contract, and it is suitable for such projects as buildings, which can be completely designed and whose quantities are thus definable, at the beginning of the project. In this type of contract, the contractor offers to do the whole work as shown in drawings and described by specifications, for a single fixed amount of money. The contractor takes the risk of being able to perform all the work for the amount specified in the contract. From the owner's **standpoint**, this is probably one of the safest contracts because cost is known up front.

Two advantages to the owner of lump-sum contracts are the fact that the total cost of the project is known before construction begins and the lack of a need to monitor and approve the contractor's costs. In addition, the flexibility of this contract form is limited: any variation from the original plans and specifications requires a change order, a process that can be time consuming and expensive and may even lead to contract disputes.

Cost-Plus-Fee Contract

Under a cost-plus-fee contract, the owner **reimburses** the contractor for all actual costs associated with the work plus a fixed fee or percentage of the cost. This type of contract is often utilized in situations where it is difficult to define the scope of the project accurately, or when time is of the essence and construction needs to start before the full plans and **specs** are completed.

For the contractor, this type of agreement guarantees a profit on the job regardless of project cost. However, the owner is at significant risk under this arrangement because there is no limit set for the project cost and the contractor really has no incentive for minimizing that cost. For this reason, it is very important that the owner clearly spells out upfront exactly which costs will be reimbursed and which costs will be viewed as part of the contractor's fee.

Unit Price Contract

Unit price contracts are used when the work to be performed cannot accurately be measured ahead of time. Unit pricing is common for heavy civil and highway-type projects. Even though engineered site plans and specs are prepared for this type of work, it is very difficult to make exact quantity estimates because the material we are working with is not something we can physically count off like **bricks** or **steel beams**. The material quantities are much more imprecise and the work is often performed by large equipment such as **bulldozers** or **backhoes** instead of by installers such as **electricians** or **carpenters**.

The risk to the owner under this contract method is obvious. The owner assumes the risk of the amount of work that is to be done. This includes the risk that the estimates of prospective work made by the owner or the architect are accurate and therefore that the total cost of the construction is accurately predicted. The contractor bears the risk that the cost of each unit of work will not rise above the unit prices specified in the contract.



## Contract strategy

Contract strategy is not an exact science. There are some guiding principles but every employer is unique in his aspirations, his circumstances and his preferences.

For some employers certainty of price is the dominant aspiration and then, given few restrictive circumstances and few particular preferences, the obvious strategic choice will be a lump sum contract with contractor. For other employers certainty of price may be secondary to considerations of quality, restrictions, or the need for a quick start and a fast finish. Which method of procurement, which type of contract, and which form of contract then become more complex questions. Some employers, on the strength of past experiences of hopes for the future, develop preferences for certain methods of procurement and certain forms of contract. Rational analysis of selection criteria to determine contract strategy may then become secondary to selection of the most suitable contractor.

## The Importance of Contracts in Construction Project

The vast majority of construction work is performed under contract. A contract is simply an agreement which obliges the parties to do specified things. Most importantly, in the case of a construction contract, it requires the contractor to build the works and requires the employer to pay for them.

Contracts have a number of different functions. In the case of a construction contract, they include:

1) specifying the work to be done by the contractor (or sub-contractor etc.), including the required quality and time for completion of various parts of the work;

2) defining what amount is to be paid, how any additional or reduced payments are to be computed and when payments are to be made;

3) defining which party is responsible for events occurring outside the parties' direct control which affect the work; such events may include bad weather, access difficulties, local authority restrictions, changes in the law, unexpectedly poor ground, etc.;

4) defining who has responsibility, for undertaking the various administrative or dispute resolution functions which may be required, including obtaining consents, giving instructions, making decisions about claims, appointing adjudicators, arbitrators, etc..

## Bond requirement

Three types of bonds are associated with construction contracts: **bid bonds**, **payment bonds**, and **performance bonds**. They are three party instruments that protect the Owner (Obligee) from damage of default by the Contractor through a bonding company (Surety).

*Bid bonds*

The bid bond is the basic means of **prequalification** for many contract bids. Unless otherwise specified by the owner, the bond may be secured from any qualified bonding company, and its purpose is to validate the bid price submitted by the contractor to the owner. This bond is submitted with the contractors bid. If the bid is accepted by the owner, the contractor must:

- Enter into a contract.
- Provide a sufficient bond for the performance of the terms.

If the contractor fails to meet either one or both of these requirements, the bid bond is forfeited.

Performance bonds

The performance bond is issued after a proposal has been accepted. It provides security in the amount of the face value, which is usually the contract price. Its purpose is to guarantee the completion of the work in accordance with the plans and specifications and at the contract price. If the contractor goes bankrupt or otherwise cannot complete the work, the bonding company becomes liable for it.

***Payment bonds***

It is also called labor and material bonds. Labor and materials payment bonds are generally issued in conjunction with performance bonds. Typically, each one has the same penalty as the

performance bond issued for a specific project. A payment bond guarantees that the contractor will pay all accounts arising from the job, thereby allowing the owner to take possession of a lien-free project at completion. To the owner, a labor and materials payment bond makes it possible for the suppliers and subcontractors to provide their products and services at the lowest cost by reducing the credit risk.

## Words and Phrases

proposal [prəˈpəuzəl] *n.* 投标
obligation [ˌɔbliˈgeiʃ ən] *n.* 义务，责任
economic efficiency 经济效益
specs [speks] *n.* 规范
productivity [ˌprɔdʌkˈtiviti] *n.* 生产率，生产力
lump sum *n.* 一次付的款额，一次付清
reimburse [ˌriːimˈbəːs] *vt.* 偿还，付还
pipeline [ˈpaipˌlain] *n.* 管道，管线
steel beam 钢梁
electrician [ilekˈtriʃ ən] *n.* 电工
carpenter[ˈkɑːpintə] *n.* 木工，木匠
prequalification 资格预审
liquidated damages 违约赔偿金
harsh [hɑːʃ] *adj.* 刺耳的，粗糙的，严厉的
standpoint [ˈstændˌpɔint] *n.* 立场，观点
brick [brik] *n.* 砖
backhoe [ˈbækhəu] *n.* 反铲挖土机
bulldozer [ˈbuldəuzə] *n.* 推土机
bid bond 投标保证
performance bond 履约保证
payment bond 支付(付款)保证



## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. In construction, it is universal practice for the contract to be ________ in the form of a written document.
2. Its main purpose is to define exactly the ________ and ________ of each party.
3. There are three basic types of construction contracts: ________, ________, and ________.
4. Three types of bonds are associated with construction contracts: ________, ________, and ________.
5. If the contractor fails to meet either one or both of these requirements, the bid bond is ________.

Ⅱ. Translate the following passages from English into Chinese.

It is common for the owner to require that the general contractor obtain a performance and

payment bond to ensure the availability of funds for completion of the work and for the payment of bills in the event of a default by the general contractor. The general contractor has a similar need to know that the owner will be able to perform his obligations under the contract.

Similarly it is important for subcontractors to be well informed about the provisions contained in contracts between the owner and the general contractor because quite often these provisions are made a part of subcontracts by reference; that is, the general contractor binds his subcontractors to all the obligations he assumes to the owner for the subcontractor's portion of the word. Subcontractors normally insist upon receiving the rights and remedies that the contractor has under his contract with the owner before agreeing to accept the responsibilities.

# 参 考 译 文

## 第 17 章　施工计划与估价

Section A　施工计划与进度管理

### 概述

计划是确定完成一项工作方案和方法的过程。同时，计划可以被认为是决定“做什么”、“怎样做”、“在何地”、“由谁”、“在什么时间”完成。在工程项目中，通常项目计划和规范规定了项目的最终结果和完成项目的一般时间期限。计划确定了事件发生的先后次序，规定了向前执行计划所采取的原则，而且描述了结果的最终状态。它为项目经理指出了需要完成的事情，它们的次序，每一项工作需要花费的时间，某项工作和行动由谁负责。

### 施工计划

在工程项目管理和实施中，施工计划是一项重要且富有挑战性的活动。一份良好的施工计划是编制工程预算和确定工程进度安排的基础。在施工管理中，编制施工计划是施工管理的一项关键工作，即使计划不是书面形式或相反已经形成正式记录。除了施工计划的技术因素之外，也有必要做出关于项目参与方之间关系以及吸纳哪些组织到项目中的组织性决策。

计划是所有管理职能的起点。有计划便有组织和人事安排，继而进行指导，控制和协调。图形计划作为一种著名的计划形式，是有效计划的基础。这种计划应该包括足够的细节，能够做出工序持续时间和时点，材料设备的数量和类型，交货日期和劳动力需求的合适安排。

一份有效计划的必要特征是：

- ◆ 它必须适合作为一种控制工具，通过它可以测量进度；
- ◆ 它必须足够准确，可以用来预测材料、劳动力、机械和资金的需求量；
- ◆ 它必须指出关于质量、范围和进度等在未来可能出现的困难， 并且提出补救措施。

计划的目标是最小化资源消耗，同时满意地完成给定的工作。计划是以确保设备、材料和劳动力的高效使用，以及确保协调力量为目标。有效的计划要求不断地检查活动，以便项目经理能预测和修订计划维持适当的进度保证目标的实现。

### 计划技术

使用最普遍和广泛的计划是横道图；网络分析，包括单代号网络图和双代号网络图。

横道图

格兰特创造了一种通过绘制横道图安排进度的方法，它是最容易理解和运用最广泛的计

划工具。在横道图中，活动是用条形表示的，穿过横道图顶部或底部的是一条时间线。对于每一个工序，一个条形将从工序的起始时间画到它的结束时间。由于它简单，容易编制，呈图解形式，横道图被广泛地用作施工进度计划工具。对于初步计划和进度安排，横道图是一个非常有用的工具。横道图简洁地显示出主要工程工序是如何被安排的。横道图的主要优势是可以编制成时间比例图。

横道图是一种表达与时间有关工序的极好方式。然而，作为一种计划技术，它也有许多缺点。尤其是项目变得更为复杂时，横道图开始变得很难为计划和进度安排提供有价值的信息。横道图的另一个劣势是，尽管可以很容易地查明具体工序的状态，但当一些工序不在按进度计划实施时，很难确定项目的整体状态。 这导致很难评估是否需要进度调整，而且也导致很难确定合适的工序进行赶工以保证目标工期的实现。

网络分析

网络分析是图形计划技术的总称，把项目看做是由工序彼此联系而成的显示工序间相互联系和实施顺序的一个网络。外加工序持续时间估计，通过数字分析网络图确定项目的预计工期。网络分析也可以识别出那些需要及时实施对项目最早竣工有重要影响的工序，以及那些可能会延误一定时间但对项目竣工不会引起延误的工序。通过计算机应用能充分发挥网络分析在处理计划数据上的优势。网络中的计划数据是通过定义工序之间的逻辑关系联系起来的。因此，任何变化都会影响到与工序有关的各种数据，例如，持续时间、资源需求等，或者影响到工序之间的逻辑关系以及重新计算和重新分配的结果。

建立网络的步骤如下：

1) 列出所有的工序；

2) 制作反映工序之间逻辑关系的网络图；

3) 估计每一个工序的持续时间，确定进度安排，并确定每一个工序的开始与结束时间以及可利用时差；

4) 估计资源的需求量。

网络分析可以提供：

- 图表中可以清晰显示施工方法：逻辑图；
- 通过计算工序持续时间，估计项目工期的方法；
- 识别对项目工期有重要影响的工序的计算方法(因此关键线路法和关键线路分析有时被用于描述这种技术)；
- 确定不影响项目按期竣工的非关键工序延误时间的计算方法。

在实际的项目管理中，网络分析的这种持续改进是最为重要的，因为它提供了一种可以充分利用可用资源的项目工序进度安排的客观方法。

**网络技术胜过横道图的优势**

当使用网络技术时，所有工序之间的相互关系是清晰可见的。标准的横道图不能做到这一点，而且因此要求计划人记住工序之间的依赖性：这对于大型项目是极其困难的，另外，现场经理必须知道工序之间是如何依赖的。

当在使用网络时发生了延误，此时需要给予关键工序特别的关注。当横道图被用于一个大型项目时，许多工序趋向于不必要的“横冲直撞”，因为几乎不可能记住哪些工序是相互依赖的。

当应用网络时，对于接管一个部分完工项目的人来说，熟悉工程进度是非常容易的。

当运用网络时，仔细地研究工序之间的顺序是非常必要的，这样会对项目有一个很好的了解。

当应用网络时，计划、分析以及进度安排是独立进行的，这样给予了计划更大的关注。

**关键线路法**

自 20 世纪 50 年代开始，关键线路法已经被广泛应用于网络分析和项目计划。

项目网络技术包括许多技术，其中一个典型方法是关键线路法。关键线路法是应用最广泛的进度计划技术。关键线路法用于施工进度计划时，需要为工程项目生命期内所有要求的工序编制图形表示。对于所有类型项目的计划和管理来说，关键线路法是一种强大的工具。本质上，它是通过示意图或网络表示项目计划的一种表现形式，这种网络阐述了项目所有组成部分的先后次序与相互关系及此网络的逻辑分析和操作，它决定了最全面的工序计划。它是一种非常适合建筑业的方法，而且提供了一种优于传统横道图的更为有用和精确的方法，形成了施工计划和控制的基础。

关键线路法最简单的解释是通过一个箭线图表示每一个施工工序。箭线的一端表示工序的开始，而另一端表示工序的结束。箭线的长度表示分配在工序上的持续时间。一些施工工序先于其他工序，而直到紧前工序结束后才能开始。其他工序可以在前面工序完成之前开始，而且一些工序可以和其他工序同时开始实施。这听起来或许很简单，但正是这种思维方式和评估方法，对于构建一个 CPM 网络是至关重要的。

然后，所有的工序将通过箭线图给出开始和结束时间以及持续时间。当两个或更多的工序箭线相遇时，交点被称为一个事件。工序流终止于事件，随后阶段的工序从一个事件前进到另一个事件。由于在施工期间，CPM 计划受到监控，各项工作通常被指定为某些数字，这些数字可以手动亦可电动来改变工作顺序或持续时间。编号方式是一种优于使用事件名称识别事件的简单方法。这些各种不同的工序、箭线以及事件被用于编制 CPM 计划，这就被称为网络。网络图构造的部分见图 17.1。



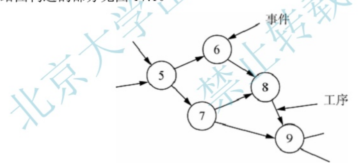



**图 17.1　只有工序 6～8 和 7～8 完成后工序 8～9 才能开始**

Section B　工程估价与成本管理

**概述**

在项目管理中，费用估算是最重要的步骤之一。费用估算确定了项目开发不同阶段的项目成本底线。项目开发特定阶段的费用估算是由造价工程师或估价人员以现有资料为基础进行的预测。估价的特点在于估价发生在实际花费之前。它试图预测未来，因此最好的情况也充满着风险，最坏的情况则是不切实际。

业主和承包商需要提前知道工程可能花费的成本。对于承包商而言，成功的投标对于企业生存是至关重要的，而成功的投标在很大程度上依赖于承包商对项目成本的估算。例如，

低估很可能赢得亏损的合同，而高估又根本不可能会赢得合同。业主的成本估算同样重要，因为低估意味着成本超支，而高估意味着浪费。造价工程师在组织中扮演着重要的角色，因为大多数工程最终成本概算的预测值是由他们编制的。由于低估和高估的代价都很高，应该给予估价工作更多的关注。

**估价的作用**

从业主的角度出发，一个早期的估价可以帮助业主确定工程项目的可购买性，现有的资金可以建设多大规模的工程项目，以及可能的质量水平。

估价为设计师提供了设计原则，设计师在业主的预算范围内选择材料和项目规模。由于工程项目是持续进行的，必须不断地把设计与预算相比较。如果设计开始超过预算，为了降低成本设计师必须确定最好的替代方案。因此，估价与设计是密切相关的。

在设计过程的结束阶段，由个人承包商编制估算以确定他们的投标价格。这些是在设计文件完成后或接近完成时所做的估价，而且是最耗时和精度最高的估价。项目管理团队通常编制详细概算以核实投标价格的准确性并以此为依据与承包商进行谈判。

**成本的类型**

项目施工过程中的成本可以划分为两种主要类型：直接成本和间接成本。

**直接成本**：属于施工工程实体消耗的成本被称为直接成本。这些成本通常与施工人员在实施工程时所使用特定材料和设备有关系。总包商在估价时应该把分包成本作为直接成本。

**间接成本**：不能归于施工工程实体消耗的成本，被称为间接成本。这些成本包括企业管理费、利润和保证金。

建立在详细设计基础上的估算将发展成包括劳动力、材料、供应和分包成本在内的直接成本定价。增加适当的间接成本以确定总的施工成本。在施工成本中增加其他的定价考虑因素以确定总的项目成本，包括价格调整、施工不可预见费和利润。

**工作分解结构**

工作分解结构是一项支持综合项目业务管理规划和监督的技术。它是一项已经成功用于管理投资组合、规划和项目的技术。工作分解结构处于项目业务管理规划的核心，因为它定义了基本的项目业务管理结构，为范围、进度、预算、数据收集情况和性能评估的开发和维护提供了框架。

工作分解结构是对工程范围的层次分解。它为汇总信息及向客户(业主)和管理做定量报告提供了一个普遍使用的、有序的、具有层次的框架。工作分解结构的目的是：(1) 为估价、成本报告以及成本跟踪提供了用标准格式收集项目成本数据的有条理的方式；(2) 为成本分类提供了一份清单；(3) 提供了一种用标准格式维护历史成本数据的方式。

**项目成本管理**

项目成本管理包括四个过程：(1) 资源计划；(2) 成本概算；(3) 成本预算；(4) 成本控制。这些过程有计划地提供了必需的成本估算，以 1) 完成项目范围；2) 基于可用的资金、管理政策和策略编制预算；3) 确保项目在批准的预算范围内完成。

为了完成工程项目，需要利用不同资源，(利用哪些资源)主要取决于工程是由内部自行完成还是由外部承包商完成。例如，劳动力、设备和信息是内部活动所必需的，但是资金是取得外部资源所必需的。

有各种估算工程成本的方法，从详细的会计程序到估测。正式的会计程序是乏味和耗费时间的，而且如果项目被放弃也许是在浪费时间。因此，在项目生命期的早期阶段，粗略的数量级估算是最好的，尽管并不是很精确。

每一个工序所需要的资源数量以及使用时间的估计是建立在工序清单和进度安排基础上的。资源分配是在工作分解结构的最底层工作包层次进行的，而资源调整是在项目层次进行的，然后才达到组织层次。除公司战略和优先考虑的项目之外，资源需求和资源可获得性的比较形成了组织层次分配决策的基础。由资源计划形成详细计划，它规定了每一个工作包所需要的资源。通过对资源计划应用资源成本费率，以及增加企业管理费和资源外取费用，从而编制出项目的成本概算。这为预算提供了基础。由于视进度安排而定，成本估算是随时间变化的，需要考虑现金流量分析。增拨也是用这种方式做出的，可以把它说成是一种管理储备，以减轻不确定性的影响。这样产生的预算就作为项目成本控制的底线。

由于不确定性，成本控制需要发现偏差，并且决定在发现偏差后怎样使项目按照预定计划和预算来实施。变更请求需要一个类似的反应。成本控制系统是建立在工作指标基础上的，比如实际的工序成本或可交付成果(里程碑)以及实际的现金流量。当项目范围发生变化时，预算底线必然也会发生变化。

**工程成本估算的类型**

在项目开发的不同阶段，工程成本估算要求的精确程度也发生着变化，从早期的相近数字到施工前预算控制时相当准确的数字。因为设计决策是在一个项目生命周期的开始阶段做出的，比那些在后期阶段做出的更具尝试性，早期阶段编制出的成本估算被认为缺乏精度。这些都是预测值，不应该被认为是100%精确的。高度的自信和现实程度依赖于工程的明确程度以及风险与不确定性的程度。通常成本估算的精度反映出在估算时可用信息的多少。

由于不同的制度要求，可以从不同的角度来看工程成本估算。尽管许多不同类型的成本估算用在项目的不同阶段，根据它们的作用，成本估算可以最大程度地分为三种主要类型。工程成本估算提供了三种基本作用中的一种：设计、投标和控制。为了确定一个项目的资金筹措计划，可以使用设计估算或者投标估算作为资金筹措计划的控制依据。

ⅰ. **设计估算**。对于业主或业主指定的设计师而言，与计划和设计一起出现的成本估算类型如下：

- 数量级估算；
- 初步估算；
- 详细估算；
- 建立在施工图和规范基础上的工程师的估算。

对于这些不同估算中的每一种来说，获得的设计信息的数量是在逐渐增加。

ⅱ. **投标估算**。对于承包商来说，提交给业主的投标估算不是为了竞争性投标就是议标，它由直接施工成本包括现场监督，外加包括一般间接费用和利润在内的标高金所组成。

iii. **控制性估算**。为了在施工期间监控项目，利用可获得的信息编制控制估算。

- 为资金筹措编制的预算性估算；
- 签订合同后，施工前的成本预算；
- 施工期间做出的竣工成本估算。

Section C　工程合同管理

**概述**

大多数的项目要求许多承包商、分包商、材料供应商、制造商以及其他参与者承担传统上已经不由工程师、建筑师或者业主来实施的工作。无论是发电站、管线系统、化工厂、办公楼，或者生产设备项目，这些组织实施各种不同的活动，并且被分配了各种不同的义务、

职责以及权利，由业主支付相应费用(资金)。通常，这些要素被归纳为书面形式并形成一份业主(买方)和承包商(卖方)之间的合同。

在建筑业中，采用书面形式合同是一种普遍的惯例。其主要目的是准确定义每一方(如业主、承包商等)的权利和义务。它准确地描述了工程的法律、财务和技术规定。通常，包括规定项目的竣工时间、违约赔偿金、关于给承包商支付的细节、需要完成工程的范围和性质等条款。合同文件由双方共同签署(业主和承包商)。它是接受报价的一方为了特定的酬金为另一方做某些事情的一份协议。在工程合同中，通常报价表现为投标(也叫出价或投标)的形式，承包商为了货币报酬(通常情况下由业主支付)，由承包商完成业主指定的工作。因此，合同的要素是报价、货币报酬和认可。

**什么是合同**

合同是一份两方或多方之间交换有价值事物的具有法律约束力的协议。在建筑业中，通常，它是用资金来交换修建设施的工程服务。合同对双方都强加了契约和法律义务，这是很难或者不可能改变的。实施合同的主要功能是鼓励经济交换，将会产生经济效益和更高的生产率。如果合同是自愿达成的，无论怎样苛刻的条款，合同必须强制执行。按照法律规定，合同当事人不能不顾协议的规定而去满足他们自己的利益或者利润。

**合同类型**

正如业主做出关于项目采购类型的决策一样，业主也得决定项目使用哪一种合同形式。通常，使用哪一种合同形式依赖于项目的类型和风险的大小，业主是否乐于接受。重要的是施工经理应该熟悉每一种合同类型。有三种基本的工程合同类型：固定价格合同，成本加酬金合同和单价计价合同。

固定价格合同

固定价格合同是最常见的合同类型，它适合于在项目的开始阶段，设计非常完善而且工程量确定的一类项目，比如房屋。在此种合同类型中，承包商以一个固定价格报价完成图纸中显示的和规范所描述的全部工程。承包商承担了按照合同中规定的数额完成所有工作的风险。站在业主的角度，这可能是最为安全的合同之一，因为成本预先就是明确的。

对于业主来说，固定价格合同有两个优势：即项目的总成本在施工前就是明确的以及不用监控和批准承包商的成本。另外，这种合同类型的可行性是有限的：因为原始计划和规范的任何变更都要求一份变更令，这个过程耗时而且花费较多，甚至导致合同争端。

成本加酬金合同

在成本加酬金合同下，业主偿付承包商为工程建设花费的全部实际成本，外加一个固定费用或者成本的百分比作为酬金。这种合同类型常用于很难精确定义项目的范围，或者当时间非常紧迫时，工程需要在详细计划和规范完成前开工这些情况。

对于承包商，不管项目成本是多少，这种类型的协议可以保证一定的利润。然而，在这种协议下业主面临很大的风险，因为对项目成本没有设定界限，所以承包商实际上没有降低成本的积极性。基于这个原因，业主应在工程开工之前清晰准确地阐明哪些成本是可偿付的以及哪些成本可以被作为计算承包商酬金的基数。

单价计价合同

单价计价合同用于当实施的工程提前不能精确计量的情况。单价计价通常用于大型土木工程和公路工程项目。即使此类工程配有施工总平面图和规范，也很难准确估算出工程量，因为我们使用的材料并不像砖或钢梁一样是可以数清具体数量的。材料的数量是更加不确定的，通常此类工程由推土机或者反铲挖土机这些大型机械代替电工或木工类的安装工人来实施。

在这种合同计价方法下业主的风险是显而易见的。业主承担拟实施工作量方面的风险。这包括业主或建筑师能否对预计工作量准确估算以及进而对施工总费用进行准确估算等方面的风险。承包商则承担了工作单元成本高于合同中规定的单价时的风险。

**合同策略**

合同策略不是万能的。有一些指导原则，只因为每一位雇主的愿望，经济情况和偏好都是不同的。

对于一些雇主来说，确定的价格是他们最大的愿望，然后，考虑到很少的限制性条件以及特定偏好，显而易见的策略选择将是与承包商签订固定价格合同。对于另外一些雇主来说，在考虑质量、约束条件，或者工程需要尽快开工和快速竣工时，确定的价格也许处于次要地位。因此，采用哪种采购方式，哪种合同类型以及哪种合同形式变成更为复杂的问题。根据过去的经验，一些雇主对于特定的采购方式和特定的合同形式具有偏好。因此，决定合同策略选择标准的理性分析，在选择最适合的承包商时已经变得不太重要。

**工程项目中合同的重要性**

大多数的施工工程是根据合同实施完成的。合同仅仅是一份约束双方完成规定事情的协议。就施工合同来说，最重要的是，它要求承包商修建工程并且要求雇主为承包商支付款项。

合同具有许多不同的功能。就施工合同而言，它们包括：

1) 规定承包商需要完成的工程(或者分包商等)，包括规定的质量等级和工程各部分的竣工时间；

2) 定义支付款项的数额，任何增加或减少的支付款项应怎样计算以及什么时候支付；

3) 定义哪一方对发生在双方直接控制之外影响工程的事件负责，此类事件包括恶劣天气、准入难度、当地权力部门限制、法律的变化、不可预见的地质条件。

4) 定义哪一方有责任承担各种行政管理或要求的争端解决功能，包括获得许可、发出指令、做出索赔决策、委派调解员、仲裁人等。

**保证要求**

与施工合同有关的保证有三种：即投标保证，支付保证和履约保证。他们是三方的正式文件，通过一个担保公司(保证人)保护业主(债权人)不受来自承包商违约的损失。

投标保证

对于许多合同投标来说，投标保证是资格预审的基本手段。除非业主规定了其他方式，保证可以来自任何有资格的担保公司，其目的是使承包商提交给业主的投标价格保持有效。投标保证是随承包商投标书一起提交的。如果承包商的投标报价被业主接受，承包商必须：

- 签订合同
- 为条款的履行提交足够的保证金

如果承包商未能满足其中一个或者这两个条件，投标保证金将被没收。

履约保证

履约保证是在投标被接受以后提交的。它为表面价值提供了保护，通常就是合同价格。它的目的是保证竣工的工程符合计划和规范的要求以及以发包价格完成。如果承包商破产或由于其他原因不能完成工程，担保公司有义务赔偿给业主所造成的损失。

支付保证

又称为劳动力和材料保证。通常劳动力和材料保证与履约保证是一起提交的。典型的是，每一种都具有相同的惩罚性，因为履约保证为特定项目提交的。支付保证担保承包商支付产生于工程的全部账目，因而允许业主占有无偿留置的竣工项目。对于业主而言，劳动力和材

料保证使得供应商和分包商通过减少信用风险以最低成本提供产品和服务成为可能。

## Grammar：科技论文的写作(Ⅳ)——正文的组织与写作

### Knowledge on Writing a Research Paper IV—Organization of main text

正文占一篇论文的大部分篇幅，是论文的主体部分。通常，它包括以下几部分的内容：一是简要介绍与论题相关的背景情况和研究现状，并提出问题；二是对所用材料、计算方法、实验设备及研究过程等的描述；三是对计算或试验研究结果进行分析讨论，提出结论和建议。由于学科、论题、方法和手段的差异，正文的组织和写作也不可能千篇一律。总的原则应该是：论文的结构层次分明，逻辑关系清晰，研究重点突出，语言文字简约。

写作情况多种多样，可采用的句型也不少。读者应结合实际情况适当选择并灵活运用，切忌死套。本节根据具体写作对象的不同，介绍一些语句结构、短语和词汇供参考。

1. 进展评述(Review Progress)

在科技论文中，尤其在引言部分，往往首先需要对目前进展和前人工作进行评述。对于这种情况，通常采用现在完成时态。若干语句结构如下：

(1) Recently this topic has been addressed in the context of…by…

(2) There has been theoretical interest in the field of…for the last decade

(3) …have attracted researchers' attention since…

(4) It has been shown by…that…have a significant effect on…

(5) …is far from simple and it is therefore desirable to…

(6) A substantial review of…has been given by…

(7) Much progress has been made in…

(8) The last decade has seen tremendous growth in the theory and methods of…

(9) The problems of…are issues which have become increasing important in 2000's.

(10) …have been a major concern in the development of…

【例 1】 Recently, there have been an interesting interest in and concern about dynamic loads，such as moving vehicles，earthquake and wind，for bridge design.

【例 2】 However，it has been observed that the previous researches could not show clearly the relationship between…because of lacking of measured data.

2. 定义与描述(Definition and Description)

在理论分析和公式推导中，常需要对一个事物或概念做出定义，并进行解释和描述。常见语句结构有：

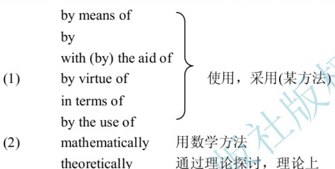
(1) …is { defined as / called / said to be } …

(2) … { is / means / signifies / is considered to be / is taken to be / refers to } …

【例 3】 B is called safety index, and is taken to be a measurement of safety level for all similar components of structures.

3. 方法及方式(Method and Way)

在阐述研究过程时，总要论及所采用的方法。在专业英语中，对方法的描述往往是句子的状语成分，内容涉及描述方法的类型、途径、意义、范围、方式等。

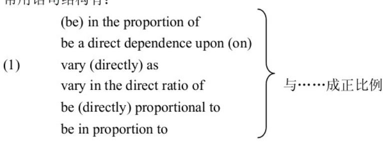



(2) mathematically 用数学方法
theoretically 通过理论探讨，理论上
statistically 用统计方法
empirically 用经验方法
experimentally 用实验方法

【例 4】 Attempts have been made to maintain and rehabilitate the existing building structures one way or another.

4. 比例和比率(Proportion and Ratio)

常用语句结构有：




(2) { vary in the inverse ratio of / be inversely proportional to / be in inverse proportion to } 与……成反比例

【例 5】 The acceleration of a body is directly proportional to the force acting and is inversely proportional to the mass of the body.

【例 6】 For mild steel loaded in elastic region，the stress varies directly as strain.

5. 图表与公式(Chart and Formula)

在科技论文中，为了更加直观、简洁和明确地表述一定的概念、理论和应用，往往采用不少图表和公式。

(1) 图。

与图有关的词汇有：graph，diagram，drawing，chart，sketch 等，如

| | |
|---|---|
| diagrammatic sketch | (示意图) |
| perspective drawing | (透视图) |
| histogram | (直方图，频率曲线) |
| curve line graph | (曲线图) |
| projection drawing | (投影图) |
| flow chart | (流程图) |

在工程图纸中常用的词汇有：plan(平面图)，side view(侧视图)，top view(俯视图)，elevation(立面图)，section(截面图)，detail(大样图)，scale(比例)等。

若论文较短，可将文中所有的图形按顺序依次编号，如 Fig．1，Fig．2，…；对于较长的学位论文或报告，可分章节编号，如 Fig. 1-1，Fig. 1-2，…或 Fig．1．1，Fig．1．2…；图名跟在其后。另外，若采用的图形引自其他文献，就需要在文中或图名后注明来源。

【例 7】As indicated in Fig.1，relative dynamic elastic is shown on the vertical axis and freeze-thaw cycles on the horizontal.

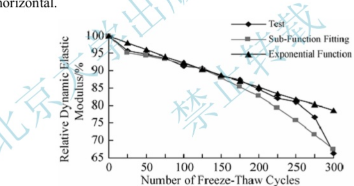



Fig.1 Change law of relative dynamic elastic modulus of fiber reinforced LWAC

(2) 表。

与表有关的词汇有：table，form，list 等。表的编号、标题的位置以及对表的来源的说明等与图的类似。注意，英语的表格一般只列横线，尽量少列竖线，几乎没有斜线。当一页不能容纳下一张表时，则在当页表后注明 to be continued 并在下页表前注明 continued。另外，对表中项目的注释，可放在表中，也可放在表外。

【例 8】 下面的实例给出了表的编排以及对表中项目说明的形式。

Table 1 Chemical complete analysis of pumice %

| $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | CaO | MgO | $TiO_2$ | $SO_3$ | $K_2O$ | $Na_2O$ | Ignition loss |
|---|---|---|---|---|---|---|---|---|---|
| 48.88 | 14.00 | 12.90 | 8.70 | 6.10 | 2.20 | 0.15 | 1.58 | 2.98 | 1.82 |

Note: Data in table is mass percent.

(3) 公式。

公式或方程在科技论文中比比皆是。如同图表编号，公式的编号可按顺序依次进行，或按章节分开进行，其位置一般在公式的右侧靠边。

**【例 9】** By analogy to Eq. (1) the equation can be rewritten **in the form of**…

句中 by analogy to (by analogy with，on the analogy of) 表示“根据……类推”；in the form ( in…form) 表示“以……形式”，如：

| | |
|---|---|
| in linear form | 以线性形式 |
| in equation form | 以方程形式 |
| in finite-difference form | 以有限差分形式 |
| in vector form | 以矢量形式 |

推导公式时，常用的词汇有：perform，proceed，derive，simplification，approximation，arrangement，algebra，positive，negative，condition，assumption 等。

6. 度量衡和单位换算(Weights and measures & units conversion)

在写作中，常常会用到度量衡和单位换算。一般在论文中采用以下两种方式处理：一是用两种度量标注数量，如 2.5 kip/ft(36.5 KN/m)；二是采用一种单位制，但在论文中或附录中列出所用到的单位换算。土木工程中常用的度量衡和单位换算见**附录 B**。

7. 常用词汇(Common Vocabulary)

调查与研究：investigate，inquire，explore，examine，look into，inspect，study，consider search，research，seek，seek out，analysis 等。

设计与准备：design，scheme，project，plan，propose，arrange，dispose，organize 等。

实验与试验：experiment，test，trial，try out，measure，record，equipment 等。

举例和例外：example，instance，case，illustration，exception，exclusion 等。

极值和均值：maximum，upper，minimum，lower，average 等。

# Chapter 18

# Real Estate and International Construction

## Section A Real Estate

### Real Estate Defined

Ask 100 people to define the term **real estate** and expect many different answers. People bring a variety of **perspectives** to discussions about real estate. To most, real estate conjures up ideas of physical combination of land and buildings. Accordingly, people often define real estate as land and all permanent **attachments** to land. To others, real estate means either a type of investment or a type of business.

### Real Estate in the World Economy

Real estate provides the space humans need and costs money to physically produce. It exists because humans put their money and effort into transforming **vacant** land into useful space. The wealth of real estate represents all previous contributions humans made to improve land and the prevailing demand and supply conditions in the asset market that affect current wealth levels. During each period, new contributions, investments, add to the level of wealth. Consequently, the **accumulated** stock of wealth and the flow of investment in real estate compared to assets indicate the relative importance of human and space relationships in the economy.



### The Real Estate Market

A market is a place where goods can be bought and sell. The function of a market is to provide a setting in which supply and demand can establish market value, making it advantageous for buyers and sellers to trade. Prices for goods and services in the market are established by the operation of supply and demand. Essentially, when supply increases and demand remains stable, prices go down; when demand increases and supply remains stable, prices go up.

### Supply and Demand in the Real Estate Market

Two characteristics of real estate govern the way the market reacts to the pressures of supply and demand: **uniqueness** and **immobility**. Uniqueness means that, no matter how identical they may appear, no two parcels of real estate are ever exactly alike; each occupies its own unique **geographic** location. Immobility refers to the fact that property cannot be relocated to satisfy

demand where supply is low. Nor can buyers always relocate to areas with greater supply. For these reasons, real estate markets are local markets. Each geographic area has different types of real estate and different conditions that drive prices. In these small, **well-defined** areas, real estate offices can keep track of both what type of property is in demand and what parcels are available.

Factors affecting supply

Because of real estate's uniqueness and immobility, the market generally adjusts slowly to the forces of supply and demand. Though a home offered for sale can be withdrawn in response to low demand and high supply, it is much more likely that oversupply will result in lower prices. When supply is low, on the other hand, a high demand may not be met immediately because development and construction are lengthy processes. As a result, development tends to occur in uneven spurts of activity. Factors that tend to affect the supply side of the real estate market's supply and demand balance include labor force availability, construction and material costs, and government controls and financial policies.

***Labor force and construction and material costs***. A shortage of skilled labor or building materials or an increase in the cost of materials can decrease the amount of new construction. High transfer costs, such as taxes, and construction permit fees can also discourage development. Increased construction costs may be passed along to buyers and **tenants** in the form of higher prices and increased rents which, can further slow the market.

***Government controls and financial policies.*** The government's monetary policy can have a substantial impact on the real estate market. The Federal Reserve Board establishes a discount rate of interest for the money it lends to commercial banks. That rate has a direct impact on the **interest rates** the banks in turn charge to borrowers. These interest rates play a significant part in people's ability to buy homes. Such government agencies can affect the amount of money available to lenders for **mortgage loans**.

Virtually any government action has some effect on the real estate market. For instance, federal environmental regulations may increase or decrease the supply and value of land in local market. Real estate taxation is one of the primary sources of revenue for local governments. Policies on taxation of real estate can have either positive or negative effects. High taxes may deter investors. On the other hand, **tax incentives** can attract new businesses and industries.

Local governments also can influence supply. Land-use controls, building codes, and zoning ordinances help shape the character of a community and control the use of land. Careful planning helps stabilize and even increase real estate values.

Factors affecting demand

Factors that tend to affect the demand side of the real estate market include population, **demographics**, and employment and wage levels.

***Population***. Because **shelter** is a basic human need, the demand for housing grows with the population. Although the total population of the country continues to rise, the demand for real estate increases faster in some areas than in others. In some locations, however, growth has ceased altogether or the population has declined. This may be due to economic changes (such as plant

closings), or population changes (such as population shifts from colder to warmer climates). The result can be a drop in demand for real estate in one area, matched by an increased demand elsewhere.

***Demographics.*** Demographics is the study and description of a population. The population of a community is a major factor in determining the quantity and type of housing in that community. Family size, the ratio of adults to children, the ages of children, the number of **retirees**, family income, lifestyle, and the growing number of single-parent and empty-nester households are all demographic factors that contribute to the amount and type of housing needed.

***Employment and wage levels.*** Decisions about whether to buy or rent and how much to spend on housing are closely related to income. When job opportunities are scarce or wage levels low, demand for real estate usually drops. The market might, in fact, be affected drastically by a single major employer moving in. Licensees must be aware of the business plans of local employers.

As we've seen, the real estate market depends on a variety of economic forces, such as interest rates and employment levels. To be successful, licensees must follow economic trends and anticipate where they will lead, how people use their income depends on consumer confidence. Consumer confidence is based not only on perceived job security but also on the availability of credit and the impact of **inflation**. General trends in the economy, such as the availability of mortgage money and the rate of inflation, will influence an individual's decision as to how to spend his or her income.

## Types of Real Property

Just as there are areas of specialization within the real estate industry, there are different types of property in which to specialize. Real estate can be classified as

- *residential*—all property used for single-family or multifamily housing, whether in urban, suburban or rural areas;
- *commercial*—business property, including office space, shopping centers, stores, theaters, hotels and parking facilities;
- industrial—**warehouses**, factories, land in industrial districts, and power plants;
- agricultural—farms, **timberland**, **ranches**, and **orchards**;
- special purpose—churches, schools, and **cemeteries**.

The market for each of these types of property can be subdivided into the sales market, which involves the transfer of title and ownership rights, and the rental market, in which space is used temporarily by lease.

## The Relative Wealth of Real Estate

Experts regularly debate the amount of value attributable to real estate. Estimates vary widely because of the difficulty in obtaining reliable information, especially outside the developed nations of the world. One set of global wealth estimates from Ibbotson Associates places the value of the world's assets at nearly $44 **trillion** in 1991, the last time a serious effort was made to perform these calculations. According to statistics, real estate outside the United States constituted 35.1 percent of the world's wealth in 1991 and U.S. real estate equaled 13.7 percent. Thus, real estate constituted nearly one half of the wealth in the world.

## The Creation of Real Estate

Development of land and construction improvements on land represents the two necessary activities for creation of the real estate people use for residential and commercial purposes. Land development is the process of changing raw land to a developed state. This process includes acquisition of land, installation of improvements to land such as streets and **utilities**, and securing zoning changes from local governments. Construction of improvements on the land is the process of bringing developed land to an improved condition in which land and buildings are ready for occupancy. Development and construction extend to significant alterations of **existing properties**, for example, renovation of retail centers and repositioning hotels.

Developers (and builders) are in business to make money. Development provides the opportunity to make (lose) enormous amounts of money. The **accomplishment** of producing permanent improvements on land also provides much satisfaction for many people. From an economic perspective, they accomplish the goal of making money from development by combining their entrepreneurial talent with proper amounts of land, labor, materials, and financial capital to produce real estate.

## Words and Phrases

real estate 房地产，房地产所有权
perspective [pə'spektiv] *n.* 前途，希望，观点，想法
attachment [ə'tætʃmənt] *n.* 附属物，附件
vacant ['veikənt] *adj.* 未被占用的，空的
tenant ['tenənt] *n.* 房客，承租人
interest rate 利率
mortgage loan 抵押借款
tax incentive 税收鼓励
well-defined [ˌweldi'faind] *adj.* 清晰可辨的；容易辨认的
accumulate [ə'kjuːmjuleit] *vt.* & *vi.* 堆积；积累
uniqueness [juː'niːknis] *n.* 唯一性；单值性；独特性
immobility [ˌiməu'biliti] *n.* 牢固，不动，固定
geographic [dʒiə'græfik] *adj.* 地理学的
demographics [ˌdemə'græfiks] *n.* 人口特征
retiree [ri'taiəriː] *n.* 退休者；退职者；退役者
inflation [in'fleiʃən] *n.* 通货膨胀
shelter ['ʃeltə] *n.* 庇护所，住所
warehouse ['wεəhaus] *n.* 仓库，货栈
timberland ['timbəlænd] *n.* 森林地
ranch [rɑːntʃ] *n.*大农场，大牧场
orchard ['ɔːtʃəd] *n.* (通常指围起来的)果园
cemetery ['semitri] *n.* 墓地，公墓
accomplishment [ə'kɔmpliʃmənt] *n.* 完成(任务等)，技能，才艺

trillion ['triljən] *n.* 万亿，兆
utilities *n.* 公用工程
existing property 现行财产

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. To most, real estate ________ up ideas of physical combination of land and buildings.
2. Prices for ________ and ________ in the market are established by the operation of ________ and ________.
3. Factors that tend to affect the supply side of the real estate market's supply and demand balance include labor force ________, ________ and ________ costs, and ________ controls and ________ policies.
4. Factors that tend to affect the demand side of the real estate market include ________, ________, and ________ and ________levels.
5. Land development is the process of ________ raw land to a developed state.

Ⅱ. Translate the following passages from English into Chinese.

Potential buyers wish to pay prices low enough to obtain adequate returns on their investments, while sellers wish to obtain prices high enough justify disposing of property. Each transaction involving the ownership or use of real estate involves similar investment calculations, whether the real estate is an owner-occupied home, an investment property, a lease arrangement, a share in a limited partnership, or some other form of ownership.

In addition to the decision to purchase and sell real estate, investment decisions recur during the period of ownership. For example, owners must repeatedly determine how much to spend on property maintenance and repair. Owners also must decide about whether to rehabilitate, modernize, and expand spaces or to convert properties to other uses. Even the decision to abandon real estate involves an investment decision.



# Section B International Construction Management

## The International Construction Industry

The extent and nature of construction undertaken throughout the world is highly dependent on wealth creation by businesses that operate nationally and/or internationally. The proportion of GDP associated with construction is generally in North America of 8-12% and therefore there is a direct relationship between the wealth of a nation and the proportion of construction that takes place.

The global construction industry is large, complex and diverse. There are five prime elements that comprise the process associated with construction on an international scale, namely design consultancy, contracting, equipment supply, products and materials and, more recently, **facility management**. The relationship between these elements depends on client requirements and the procurement method selected for the delivery of the projects. Whatever method is adopted, project

management will play a key role in the efficient execution of construction projects. Therefore the selection of appropriate systems and organization structures is of crucial importance. The nature of large projects procured overseas using resources from different countries and continents requires, as a fundamental **prerequisite**, a high degree of coordination and communication.

Consultants who have specialist expertise in design and management have considerable potential to operate on a global scale and this has been made more possible by recent advances in information technology. **Unprecedented** immediate access is now available to all the expertise contained within major consultancy practices by means of the Internet and it is now possible to dynamically generate innovative solutions to problems collaboratively, **irrespective** of geographical location. Many consultants have set up a network of overseas offices to reflect the growth in construction activity and their particular specialisms. Moreover, it is now common practice to employ **indigenous** design professionals who have knowledge of local conditions.

Global contracting in 1994 was dominated by Japanese companies, but by 2001 contractors from the USA and Europe, who had advanced sufficiently to mount a successful challenge, had broken this domination. Construction companies from **NIC** have still to make a significant impact on the international construction scene, although it is clear that China State Construction Corporation is a fast growing international player which will potentially provide tough competition.

Materials suppliers and **component** manufacturers have experienced major developments in technology and **manufacturing processes**. Efficiency gains have been made in the processing of raw materials and product design has been improved to provide greater efficiency and in-use performance. The expansion of the global construction market has led to widespread mergers and acquisitions aimed at achieving national, regional and global market advantage. The largest and most successful organizations are currently seeking to create global networks for the **exploitation** of their materials and products.

Equipment manufacturers have a long track record of operating globally. Japanese manufacturers have joined the international trade in **earthmoving** equipment, once dominated by American corporations, e.g. Caterpillar has a joint venture with Mitsubishi Heavy Industries and Komatsu have built a worldwide reputation. European manufacturers such as Leibherr and Potain have been leaders in the manufacture of **tower cranes**, but now there is worldwide competition from USA, Scandinavia, China and the Russian Federation.

Property and facility management is still growing in **prominence**. The development of facility management has been made more significant by increasing demands emanating from environmental issues and the continuing trend in privatization. Industry has responded by embracing the growing practice of **private public partnerships** (PPP) and the use of private funds to support public projects. Such projects normally incorporate a concession to allow the potential for organizations delivering construction projects to extend their involvement by participating in the income generated from the completed building. Such arrangements take a number of different forms from Build Operate and Transfer to **Private Finance Initiative** where a **concessionaire** generates funds for the design and construction of the project, which will be set against **operating income** over a specified time period.

International trade in construction goods and services concerns a range of economic

transactions, which occur across national boundaries between two or more organizations for mutual direct or indirect benefit. Orders are placed and contracts are awarded internationally when an organization in one country has gained competitive advantage over competitors in other countries, usually by exploiting expertise, low labor costs and indigenously occurring raw materials. However, the motivation to export and import goods and services will in some cases be subjected to moderation by national regulations that keep close control over the balance of exports and imports to ensure that national economies remain stable. Construction spending in 2000 represented a total of 2,722,980 million US$ and dispersion over world regions is shown in Table 18-1.

Table 18-1 Dispersion of construction spending

| Region | Million US$ | % |
|---|---|---|
| North America | 903,340 | 33.175 |
| European Union | 641,160 | 23.546 |
| Asia and Japan | 683,820 | 25.113 |
| Russia & E. Eur. | 80,790 | 2.967 |
| South America | 136,790 | 5.024 |
| Middle East | 49,400 | 1.814 |
| The Rest | 227,680 | 9.361 |
| Total | 2,722,980 | 100 |

Source: Generated from World Development Indicators, World Bank 2001



## International Construction Profits

Profits are an interesting but usually confidential aspect of project costs. Despite this, it is possible from company annual reports to develop a reasonable estimate of the level of profit involved, which presumably is derived from projects.

**ENR**(1995a) refer to **gross profit** for contractors in the region of 2.5% to 5% with **net profit** generally less than 1%. This is very much in line with the performance of contractors in the UK. Since international work is viewed as more risky, presumably most companies would look to top end of the range suggested. Of course in situations where there is greater **leeway** there is always the desire to look for higher profits.

## The Construction Market: Future Opportunities

Macrochanges in the world economy at large, and the construction market in particular, are creating new opportunities for **forging** alliances between construction firms, particularly those of medium size.

Developments in information processing and telecommunication technologies, global procurement of materials and equipment, improved **transportation** infrastructures and **internationalization** of financial markets allow firms to enter new markets by operating worldwide. The collaboration with local firms is essential for understanding local markets, cultures and technologies without the need for significant investments, such as the opening of a local **subsidiary**, and for developing the awareness of the competitive requirements of the global economy.

At the same time the need for creative project financing (required by privatization programs and lack of public funds) and real estate and facilities operations and maintenance is expanding the traditional opportunities of the construction industry. Its market has been characterized by an increasing demand for broad management services to be offered early in the building process in addition to traditional construction services. The increasing complexity of projects with regard to both phasing and technology requires capabilities to cooperate with different specialized organizations and/or to deliver total and **multidisciplinary** services. These new challenges can be met if construction firms can develop technical and integrative management capabilities applicable to entire building process, and a professional service attitude instead of a production-oriented culture. These capabilities should be supported by the increasing involvement of construction firms early in the development of new projects.

## Case Study: Hong Kong Airport

The new Hong Kong Airport would be viewed by many as a prime example of an international construction project. It is an impressive project in terms of scale and technical difficulty, requiring a 1248 hectare **reclamation** and airport platform, a 34 km road and rail link to the central business district and 35,000 construction workers. The total cost of US$20bn ranks as one of the largest infrastructure developments of the world. Political tension between China and Britain, the monsoon weather of Hong Kong, the density of population around which work needed to be carried out and the huge scale of reclamation all added to the difficulty, and yet the original estimate was reduced by approximately 6% in the final out-turn cost.

The project required special labour importation legislation in order to meet the need for 35,000 workers; 225 construction contracts were agreed and signed, with 182 of these being for major work. The work by value was won by firms from the following countries and regions: Hong Kong(23%), China(8%), Japan(26%), Britain(16%), Holland(6%), France(5%), Belgium(3%), New Zealand(3%), Australia(2%), US(2%), Spain(2%), Germany(2%) with smaller splits to Italian, South African, Austrian, Norwegian, Portuguese, Swedish and Danish firms.

At its peak the reclamation work required 18 of the world's largest **dredgers** working continuously 24 hours a day for 20 months.

Design of road and utility infrastructure needed to be sufficient for a working population of 45,000(**equivalent** to new town). The passenger terminal designed to **accommodate** 35 million passengers per annum.

## Words and Phrases

facility management 设备管理
prerequisite [ˌpriːˈrekwizit] *n.* 先决条件，前提
unprecedented [ʌnˈpresidəntid] *adj.* 前所未有的，无前例的
irrespective [ˌirisˈpektiv] *adj.* 不考虑的，不顾的
exploitation [ˌeksplɔiˈteiʃən] *n.* 宣传，广告
earthmoving [ˈəːθˌmuːviŋ] *adj.* 大量掘土(或运土)的
prominence [ˈprɔminəns] *n.* 声望，杰出

private public partnerships (PPP)公共私营伙伴关系
private finance initiative 私人主动融资
operating income 营业收入
concessionaire [kənˌseʃəˈnɛə] *n.* 受让人，特许权获得者
indigenous [inˈdidʒinəs] *adj.* 土生土长的，当地的
ENR *abbr.* Engineering News-Record 工程新闻记录。是工程建设界国际知名的杂志，由美国 McGraw-Hill 公司出版。其每年评出的“国际工程承包商 225 强”成为评价国际工程承包商的重要参考。《工程新闻记录》第一期于 1917 年 4 月 5 日出版。1987 年 1 月 1 日，其缩写 ENR 正式成为该刊刊名。
NIC *abbr.* National Industrial Council (美国)全国工业理事会
component [kəmˈpəunənt] *n.* 部件
manufacturing process 制造工艺
leeway [ˈliːwei] *n.* 灵活性，落后
forging [ˈfɔːdʒiŋ] *n.* 锻炼，伪造
tower crane 塔吊，塔式起重机
internationalization [intəˌnæʃənəlaiˈzeiʃən] *n.* 国际化
transportation [ˌtrænspɔːˈteiʃən] *n.*运送，运输
subsidiary [səbˈsidiəri] *n.* 子公司，附属机构
multidisciplinary [ˌmʌltiˈdisiplinəri] *adj.* 包括各种学科的，有关各种学问的
reclamation [ˌrekləˈmeiʃən] *n.* 填筑
equivalent [iˈkwivələnt] *adj.* 相等的，相当的
accommodate [əˈkɔmədeit] *vt.* 容纳，使适应，顺应
gross profit 毛利，总利润
net profit *n.* 净利，纯利
dredger [ˈdredʒə] *n.* 挖泥船



## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. The global construction industry is ________,________ and ________.

2. Materials suppliers and component manufacturers have ________ major developments in technology and manufacturing processes.

3. Property and facility management is still growing in ________.

4. Whatever method is ________, project management will ________ a key role in the efficient execution of construction projects.

5. Profits are an ________ but usually ________ aspect of project costs.

Ⅱ. Translate the following passages from English into Chinese.

Contractors’ attention is being directed to the Far East. The developing nations of the Pacific Rim and SE Asia, especially PRC, to which UK organizations may gain advantageous entrée through Hong Kong, are very attractive areas. However, highly competitive companies from Japan, USA etc. will seek work in the area too.

The UK construction market will see expansion in infrastructure projects; repairs, maintenance and refurbishment will feature strongly. Contractors will offer specialized services, often through consortia. Partnering schemes will expand. Developments in IT and CAD will continue with more attention to compatibility and integration of systems. Attention to environmental issues is essential. Internationalization into a global market will continue with increased attention on the Far East and Pacific Rim, Central and Eastern Europe (subject to political stability).



## Section C Project Risk Management

### Introduction

Risk is defined in Webster's dictionary as the chance of injury or damage or loss. While this obviously is a general definition of risk, construction risk can also be related to the chance of loss associated with three primary constraints: time, cost, and quality.

In construction projects each of the three primary targets of cost, time and quality will be likely to be subject to risk and uncertainty. It follows that a realistic estimate is one which makes appropriate allowances for all those risks and uncertainties which can be anticipated from experience and foresight. Project managers should undertake or propose actions which eliminate the risks before they occur, or reduce the effects of risk or uncertainty and make provision for them if they occur when this is possible and cost effective. It is vital to recognize the root causes of risks, and not to consider risks as events that occur almost at random. Risks can frequently be avoided if their root causes are identified and managed before the adverse consequence—the risk event—occurs. They should also ensure that the remaining risks are allocated to the parties in a manner which is likely to optimize project performance.



### Construction Risks

Construction projects have an abundance of risks, contractors cope with it and owners pay for it. The construction industry is subject to more risk and uncertainty than many other industries. For years, industry has had a very poor reputation for coping with the adverse effects of change, with many projects failing to meet deadlines and cost and quality targets. Change cannot be eliminated, but by applying the principles of risk management, engineers are able to improve the effective management of this change.

Typical risks on a construction project include:

- failure to complete within the stipulated design and construction time;
- failure to obtain the expected outline planning, detailed planning or building code/regulation approvals within the time allowed in the design programme;
- **unforeseen** adverse ground conditions delaying the project;
- exceptionally inclement weather delaying the project;
- strike by the labour force;
- unexpected price rises for labour and materials;
- failure to let to a tenant upon completion;

- an accident to an operative on site causing physical injury;
- latent defects occurring in the structure through poor **workmanship**;
- **force *majeure*** (flood, earthquake etc.);
- a claim from the contractor for loss and expense caused by the late production of design details by the design team;
- failure to complete the project within the client's budget allowance.

## Cost of Risks

The cost of risks to an organization, whether managed or not, can have a significant impact on its **balance sheet**. The cost of risk management itself results from the costs incurred by the identification and evaluation of risks, control measures that might be put in place (such as better security provisions, standby plant), the costs of insurance or other financing provisions, and the fees for any outside consultants.

These definite costs must be weighed against the costs if hazards occur, e.g.

- direct costs of loss—repairs or replacement of damaged goods or property, third party **compensation;**
- measurable consequential costs of loss—loss of, or reduced output, **knock-on effect** on production chain, losses whilst retraining replacement staff or becoming familiar with replacement equipment, accident investigation costs, lost management time involved in **litigation**, increased **premiums**;
- indirect costs of loss—inability to meet contracts, loss of market share, loss of **goodwill**, poor **industrial relations**, poor workplace **morale**, recruitment problems, adverse press relationship.



## Risk Management

Risk management, as it relates to construction projects, is vital to the successful undertaking and completion of any construction process, as projects tend to be more complex and competition increasingly tougher. In virtue of construction operations typically involve the coordination of resources (i.e., labor, materials, and equipment) to achieve a desired cost, schedule, quality, safety objective, sources of variability can be primarily attributed to such things as labor productivity, regional wage rates, and the availability and cost of materials and equipment. Unfortunately, many contractors are unfamiliar with these risk factors and do not have the experience and knowledge to manage them effectively. As a consequence, late completion, poor cost performance and business failures are commonplace in the construction industry.

## The Importance of Risk Management

Risk management provides support for attempts to gain better control over a project when it comes to time(planning/schedules),money(estimates),quality, information and organization. It does this by siring thought beforehand to the undesirable future events or outcomes that might occur in a project, so that decisions may be made to take action early on in order to prevent or reduce the impact of these events. Risk management is an important part of the **decision-making** process in

construction, and now widely accepted as a vital tool in the management of projects.

Risk management can help to:

- promote an uninterrupted progression of the activities within a project and, by **implementing** the appropriate measures, remove any interruptions as quickly as possible should they occur;
- instil confidence in the project, in third parties, and in the project team itself;
- promote communication within the project;
- support the decision-making process within a project.

However, we use risk management to try to look ahead and it is therefore not a judgment of events after the fact.

## Risk Management Steps

Probability, frequency, impact, importance, and **exposure** are the necessary factors in analyzing the four vital steps in risk management. These steps are: risk identification; risk analysis; risk repose; risk control.

Risk identification

Considerable effort occurs in identifying and ranking the processes, or components, of a project, its major goals, and its risks. This identification step is closely allied with the next step, risk analysis. To be effective, risk identification requires considerable up-front planning and research. Project managers need to determine the analysis technique to use; select the primary participants who are to perform the risk identification; allow participants time to perform it; and decide where to conduct it. For research, they must review project plans, interview people, calculate statistics and metrics; and peruse technical documentation.

Risk analysis

Project managers convert data collected during the risk identification step into information using a selected technique. Two categories of risk analysis exist: quantitative and qualitative. Quantitative techniques rely heavily on statistical approaches, such as the **Monte Carlo simulation**. Qualitative techniques rely more on judgment than on statistical calculations, such as **heuristics**. The purpose of risk analysis is to quantify the effects on the project of the risks identified.

Consider Fig. 18.1 which compares the probability of occurrence of an event compared with its impact on the construction project. Events with a low impact are not serious and can be divided into the elements of **trivial** and expected. For the high impact and low probability, these events are a hazard which could arise but are too remote to be considered. In project management however, high impact risks should not be ignored even if their probability is low. Fallback and response plans should be put in place even if the financial impact is too large to be covered by contingencies. The use of risk management is to identify, assess and manage those events with both it high impact and a high probability of occurrence.

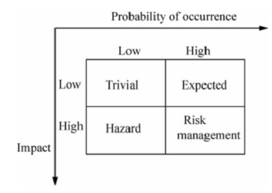



Fig. 18.1 Classification of risk sources

Risk response

The response to the risk will be appraised by the severity of the risk to the project. There are four risk **mitigation** strategies that can be adopted by the client and project team in order to reduce the **risk exposure** associated with a project: **avoidance**, reduction, transfer or **retention**.

***Avoidance.*** If the situation is assessed whereby the risk is judged to have such a serious consequence, then the situation may warrant a reappraisal of the project. It may be necessary to review the project's aims, either to reappraise the concept or to cancel the project.

***Reduction.*** Reducing the risks may involve redesigning the project, changing the procurement strategy or undertaking additional soil investigation to minimize changes to the foundations, changing the specification or incorporating different methods of construction to avoid unproven construction techniques.

***Transfer.*** There are four common routes for the transfer of risk:

- client to contractor;
- contractor to subcontractor;
- client, contractor, subcontractor or designer to **insurer**;
- contractor or subcontractor to **surety**.

If risks can be transferred, their consequences can be shared or totally carried out by someone other than the client. The client will be expected to pay a premium for this, so responsibility for initiating this form of risk response lies with the client.

***Retention.*** Risks that are retained by either party may be controllable or uncontrollable by that party. Where control is possible it may be exerted to reduce the likelihood of occurrence of a risk event and also to minimize the impact if the event occurs. It will be necessary to include a project **contingency** fund.

Risk control

Project managers identify the measures, or controls to establish, to lessen or avoid the impact of a risk on a process or component. Project managers can take one of two approaches towards risk. They can react to risk: that is, wait for it to occur before taking any action—for example, they hire more people at the last minute. Or, they can be proactive: that is, establish plans and an **infrastructure**—for example, they set up an early warning system, to prepare their projects to

detect and handle expected risks.

## Words and Phrases

litigation [ˌliti'geiʃən] *n.* 诉讼
unforeseen [ˌʌnfɔː'siːn] *adj.* 未预见到的，意料之外的
force majeure 不可抗力
workmanship ['wəːkmənʃip] *n.* 技艺，工艺
balance sheet 资产负债表
implement ['implimənt] *vt.* 使生效，贯彻，执行
compensation [ˌkɔmpen'seiʃən] *n.* 补偿物，补偿金
premium ['priːmiəm] *n.* 保险费奖；奖金，额外费用
goodwill ['gud'wil] *n.* 信誉，声誉
morale [mɔ'rɑːl] *n.* 士气；斗志
decision-making *n.&adj.* 决策(的)
heuristics [hjuə'ristiks] *n.* 启发法，探索法
trivial ['triviəl] *adj.* 琐碎的，没有价值的，没有意义的
Monte Carlo simulation 蒙特卡罗模拟法
exposure [iks'pəuʒə] *n.* 暴露，显露，揭发，揭露
risk exposure 风险承担
surety ['ʃuəti] *n.* 担保,保证
contingency [kən'tindʒənsi] *n.* 不可预见费，应急费
infrastructure ['infrəˌstrʌktʃə] *n.* 基础设施；基础结构
knock-on effect 撞击作用
industrial relations 劳资关系
insurer [in'ʃuərə] *n.* 承保人，保险公司
mitigation [ˌmiti'geiʃən] *n.* 缓解，减轻，平静
avoidance [ə'vɔidəns] *n.* 回避，避开，避免
retention [ri'tenʃən] *n.* 保持，保留，容纳

## Exercises

Ⅰ. Fill in the blanks with the information given in the text.

1. Risk is defined in Webster's dictionary as the chance of ________ or ________ or ________.

2. Unfortunately, many contractors are ________ with these risk factors and do not have the ________ and ________ to manage them effectively.

3. As a consequence, late ________, poor ________ performance and ________ failures are ________ in the construction industry.

4. ________, ________, ________, ________, and ________ are the necessary factors in analyzing the four vital steps in risk management.

5. Two categories of risk analysis exist: ________ and ________.

Ⅱ. Translate the following passages from English into Chinese.

The construction industry is subject to more risk and uncertainty than many other industries. The process of taking a project from initial investment appraisal to completion and into use is complex, generally bespoke, and entails time-consuming design and production processes. It requires a multitude of people with different skills and interests and the co-ordination of a wide range of disparate, yet interrelated, activities. Such complexity moreover, is compounded by many external, uncontrollable factors.

In view of the inherent risks in construction, it is surprising that the managerial techniques used to identify，analyze and respond to risk have been applied in the industry only during the last decade. Most people would agree that risk plays a crucial role in business decision-making：the risk of loss tempers the pursuit of return. Essentially, it stems from uncertainty, which in turn is caused by a lack of information.

## 参 考 译 文

### 第 18 章　房地产与国际工程

Section A　*房地产*

**房地产的定义**

让 100 个人给房地产下个定义，会产生许多不同的答案。在讨论房地产时，人们对房地产有自己不同的观点。多数人认为，房地产是土地和建筑物的物理连接。因此，通常人们对房地产的定义是土地和土地上的所有永久性附属物。对其他人而言，房地产意味着一种投资类型或是一种商业类型。

**世界经济中的房地产**

房地产为人类提供了需要的生活空间并且需要我们耗费资金进行建设。它之所以存在，是因为人类投入他们的资金和努力，把空闲的土地转化成对人类有用的空间。房地产的财富代表了人类为改善土地做出的所有的早先贡献，资产市场中主要的需求供给状况会影响当前的财富水平。在每一个时期，新的建设、投资，都会增加财富水平。因此，在房地产市场中，财富的积聚程度和投资流向与资产相比揭示了在经济中人类与空间关系的相对重要性。

**房地产市场**

市场是人们进行货物买卖的地方。市场的功能是提供一个供给和需求能确定市场价值的场所，为买方和卖方交易提供便利条件。市场中货物和服务的价格是通过供给与需求的作用确定的。本质上，当供给增加，需求保持不变，价格会下降；当需求增加，供给保持不变，价格会上升。

**房地产市场中的供给与需求**

房地产的两个特征控制着市场对供给与需求压力的反应方式，即唯一性和固定性。唯一性表示，无论他们怎样相同的出现，在任何时候没有两个房地产是完全相似的，每一个都坐落在各自唯一的地理位置。固定性反映出一个事实，当供给很少时，房地产不能被重新部署以满足需求。买方也不总是随着大量的供给而迁移区域。基于这些原因，房地产市场是个区域市场。每一个地理区域拥有不同类型的房地产和不同的环境导致价格变化。在这些局部明

确的区域，房地产部门能了解房地产需求的类型以及可获得的类型。

影响供给的因素

由于房地产的唯一性和固定性，通常市场对供给和需求压力的调整是缓慢的。虽然一个公开出售的住宅可以被取消以对低需求和高供给做出响应，但是过度供给很可能导致更低的价格。在另一方面，当供给很少时，高需求不会被立即满足，因为开发和建设是一个漫长的过程。因此，开发是一种不均衡的活动。很多因素趋于影响房地产市场供给需求平衡的供给这一边，包括劳动力可获得性，施工和材料成本，以及政府调控和财政政策。

**劳动力、施工和材料成本**。熟练工人或建筑材料的短缺，或者材料成本的增加能减少新工程的数量。高转移成本，例如税费和施工许可费也会阻碍开发。增加的施工成本可能会通过更高的价格和增加租金的形式传递给买方和承租人，从而进一步减缓了市场需求。

**政府调控和财政政策**。政府的货币政策对房地产市场有着重要影响。美国联邦储备委员会为商业银行贷款确定了一个利息贴现率。这个贴现率对银行回收借款人的贷款利率有直接影响。这些利率对于人们购买房子的能力有着重要影响。这些政府机构就能影响贷款人获得抵押贷款资金的数量。

实际上，任何政府行为对房地产市场都有一定的影响。例如，联邦环境条例可以增加或者减少区域市场土地的价值和供给。房地产税是地方政府税收的主要来源之一。房地产的税收政策对房地产市场或有积极影响或有消极影响。高税收也许会阻止投资者投资。另一方面，税收鼓励能吸引新的商业和工业。

地方政府也能影响供给。土地利用计划调控，建筑规范，以及区划法规对一个地区的特征和土地的利用调控有重要影响。详细的计划有利于稳定，甚至增加房地产价值。

影响需求的因素

影响房地产市场需求方面的因素包括人口，人口特征，就业和工资水平。

**人口**。因为居住是基本的人类需求，住房需求随着人口增长而增加。虽然一个国家的总人口是在持续增长的，房地产的需求在某些地区要比其他地区增长的更快。然而，在某些地区，增长已经完全停止，或者人口已经下降。这也许会导致经济转变(如工厂倒闭)，或者人口变动(如人口从寒冷地区迁移到气候温暖的地区)。这种结果导致某些地区房地产需求下降，与之相对应的是其他地区需求增加。

**人口特征**。人口特征是人口的类型与研究。一个地区的人口是决定此地区住房数量和类型的主要因素。家庭规模，成年人与孩子的比率，孩子年龄，退休人员数量，家庭收入，生活方式，以及单亲家庭和空巢家庭增加的数量都是人口因素，这些因素会对住房需求类型和数量产生影响。

**就业与工资水平**。关于是买还是租以及在住房上花费多少的决定与收入是紧密相关的。当工作机会减少或者工资水平很低时，房地产的需求通常是下降的。事实上，市场也在很大程度上受一个新加入的大雇主所影响。执照持有者必须知道当地雇主的经营计划。

在我们看来，房地产市场依赖于多种的经济力量，比如利率和就业水平。为了取得成功，执照持有者必须紧跟经济走势，而且期望他们在那里引导人们如何使用他们的收入依赖于消费者信心。消费者信心是建立在感觉到的工作保障，以及贷款的可获得性和通货膨胀影响的基础上。经济的总体趋势将会影响个人怎样花费他的或者她的收入的决策，比如抵押贷款的可获得性和通货膨胀率。

**房地产的类型**

正像房地产业中的专门领域，存在不同类型的房地产专业领域。房地产可以划分为：

- 住宅地产——无论城市、郊区或者农村，所有用于单个家庭或者多个家庭居住的房地产；
- 商业地产——商业地产，包括写字楼，购物中心，百货店，剧院，宾馆和停车场；
- 工业地产——仓库，工厂，工业区用地和发电厂；
- 农业地产——农场，林场，牧场和果园；
- 特殊目的地产——教堂，学校，公墓。

这些房地产市场类型中的每一种可以被细分为销售市场，包括产权和所有权的让渡；以及租赁市场，通过租赁方式临时使用。

**房地产的相对财富**

专家经常争论房地产的价值总量。但是评估的差别很大，由于在可靠信息获取上存在困难，尤其是在世界发达国家之外的国家。一组来自 Ibbotson Associates 公司全球财富估计数据显示，1991 年世界资产的估定价值接近 44 万亿美元，这些是通过长时间的认真努力计算出来的。根据统计，除美国之外的房地产价值占到了 1991 年全世界财富的 35.1%，而美国的房地产占到了 13.7%。因此，房地产在全世界的财富中占到接近一半的比重。

**房地产的创造**

土地开发以及土地上设施的建设代表了人们用来居住或商业目的房地产创造的两项必要活动。土地开发是把生地转变为熟地的过程。这个过程包括土地的取得，土地设施的安装工程，比如街道和公用工程，以及当地政府原有分区变化。土地上设施的建设是把熟地转变为一种改良状态，以便土地和建筑物准备用于使用。开发和建设达到对现有房地产的重要改造，例如，零售中心和旅馆的整修。

开发商(和建造商)在做买卖赚钱。开发提供了赚取(亏损)大量金钱的机会。土地上生产永久性设施的建设完成也为许多人提供了许多满足。从经济的观点来看，通过把企业家才干与适当数量的土地、劳动力、材料和资金相结合开发房地产，他们实现了从开发中赚钱的目标。

## Section B 国际工程管理

**国际工程业**

全世界承揽的工程的范围和类型高度地依赖于通过在国内或者在国际经营商业创造的财富。在北美地区，建筑业创造的价值占 GDP 的比例是 8%～12%。因此，一个国家的财富与建筑业的比重之间具有直接的关系。

全球建筑业规模巨大，复杂多样。与国际工程有关的业务由 5 个主要部分组成，分别是：设计咨询、施工承包、设备供应、产品和材料，以及最近以来的设备管理。这些组成部分之间的关系依赖于业主需求和项目采购方式的选择。无论采用哪一种方式，项目管理在工程项目的高效实施中将起到非常重要的作用。因此，合适的采购方法和组织结构的选择是至关重要的。利用不同国家和地区的资源，承接海外大型项目的关键需要有效的协调和沟通，这是基本的前提条件。

咨询顾问在设计和管理方面拥有专长，有在全球范围内经营业务的巨大潜能，通过信息技术的新发展，这更加成为可能。如今，依靠因特网方式，包含主要咨询惯例在内的所有咨询知识可以史无前例的快速直接获得，而且不管地理位置在何处，如今通过动态协作产生解决问题的革新方法成为可能。许多咨询顾问已经建立了一个海外办事处网络以考虑建筑活动的增长和他们的特别专长。此外，如今雇佣掌握当地情况知识的本地设计师是一种普遍做法。

1994 年全球施工承包市场被日本公司所统治，但是到 2001 年，来自美国和欧洲的承包

商，发展十分迅速并且取得了很大的成功，打破了日本公司的统治局面。来自(美国)全国工业理事会的建筑公司对国际工程市场具有重要的影响，然而清晰地看到中国建筑股份有限公司是一个快速增长的国际竞争对手，这将会带来激烈的竞争。

材料供应商和零部件生产商已经经历了科技和制造工艺的主要发展历程。原材料的加工处理使得效率提升，而且产品设计已经得到改良，产生了更高的效率和使用性能。全球建筑市场的扩张已经导致以实现地区，国家及全球市场优势为目标的广泛的收购和兼并。当前最大和最成功的组织正在寻求创建他们的材料和产品的全球宣传网络。

设备制造商拥有长期的全球运营记录。日本制造商已经加入了掘土设备的国际贸易，这个市场曾经由美国公司所控制。例如卡特彼勒是由三菱重工和小松组成的联营体，在世界范围内已经赢得了很好的声誉。欧洲制造商，例如利勃海尔集团和波坦公司已经是塔式起重机产品的领军企业，然而现在有来自美国、北欧、中国和俄罗斯的全世界范围的竞争。

资产和设备管理仍然显著增长。由于来自于环境问题需求的增加和私有化程度的持续增长，设备管理的发展显得更加重要。通过包括公共私营伙伴关系(PPP)的不断实践以及私人资金支持公共项目的运用，行业已经做出回应。通常此类项目给予一定的特许权允许有发展潜力的组织交付工程项目，通过分享产生于竣工建筑物的收入以回收他们的投入。此类协议可以采取许多不同的形式，从建设-经营-移交到私人主动融资，特许权获得者将通过在一个规定期间内取得营业收入抵偿其为项目设计和施工提供的资金。

建筑商品和劳务的国际贸易关注一系列的经济运作，这些发生在跨越国界的两个或多个具有共同直接或间接利益的组织之间。当某个国家的某个组织较其他国家竞争者更具有竞争优势，通常通过开拓专业技能，利用低廉的劳动力和本土产的原材料，获取国际订单及授予合同是顺理成章的事。然而，在有些情况下，进出口商品和劳务的动机将遵守国家规范的调控，这样对进出口的平衡起到严密的控制作用，以确保国家经济保持稳定。2000 年建设投资总计为 2.722 98 万亿美元，世界范围内的分布见表 18.1。



表 18.1 建设投资的分布

| 地区 | 百万美元 | % |
|---|---|---|
| 北美 | 903 340 | 33.175 |
| 欧盟 | 641 160 | 23.546 |
| 亚洲和日本 | 683 820 | 25.113 |
| 俄罗斯和东欧 | 80 790 | 2.967 |
| 南美 | 136 790 | 5.024 |
| 中东 | 49 400 | 1.814 |
| 其他 | 227 680 | 9.361 |
| 总计 | 2 722 980 | 100 |

来源：2001 年世界银行世界发展指标

### 国际工程利润

项目成本里利润是人们关注的但通常又是很机密的一个因素。尽管这样，公司年度报告中也有可能披露较合理的项目利润水平预计值。

1995 年工程新闻记录指出承包商的毛利润是 2.5%到 5%，通常净利润小于 1%。这与英国承包商的业绩是非常一致的。因为国际工程被认为更具风险性，可能大多数的公司向建议排序的顶端看去。当然，如果有争取更大的余地的机会，人们总是渴望寻求更高的利润。

### 建筑市场未来展望

世界经济特别是在建筑市场普遍的巨大变化，为各建筑公司特别是中等规模的公司之间的结盟正在创造新的契机。

信息处理和电信技术的发展，材料和设备的全球采购，改进的运输基本设施和金融市场的国际化允许企业通过世界范围的运作进入新市场。在无重大投资需求，像开设当地子公司的情况下，与当地企业的合作对于理解当地市场，文化和技术及唤起全球经济竞争需求意识是必要的。

然而，创造性项目融资(私有化程序和公共资金缺乏导致的)、房地产以及设施运营与维护的需求正在扩大建筑业的传统机遇。它的市场特点在于除了传统的建筑服务之外，在建设过程早期阶段所提供的广泛管理服务的需求在不断增加。项目定位和技术不断增加的复杂性要求具有不同能力的专业组织进行协作，以及提供全部的和包括各种学科的服务。如果建筑企业完善技术和综合管理能力并应用在整个建设过程中，以及用专业服务态度代替以产品为导向的文化，可以实现这些新的挑战。这些能力应该在新项目早期开发阶段通过增加建筑公司的投入来实现。

**案例：香港新机场**

中国香港新机场被许多人认为是国际工程项目的一个典型案例。从其规模和技术难度方面来说，它是一个令人印象深刻的项目，其中 1248 公顷的填筑工程和机场平台，34 公里长的公路和铁路快线连接商业中心区，35 000 名建筑工人。香港新机场总投资 200 亿美元，是世界最大的基础设施项目之一。中国和英国之间的政治紧张，香港的季风气候，工地附近的人口密度以及巨大的填筑规模，所有这些都增加了工程的难度，而且在最终成本中最初估算大约被削减了 6%。

为了满足 35 000 名工人的需求，项目要求为特别的劳动力输入立法，接受和签署了 225 份建设合同，其中的 182 份是大型工程。这些工程按照价值由来自下面这些国家和地区的企业获得：中国香港(23%)，中国(8%)，日本(26%)，英国(16%)，荷兰(6%)，法国(5%)，比利时(3%)，新西兰(3%)，澳大利亚(2%)，美国(2%)，西班牙(2%)，德国(2%)，其中有很小一部分分与意大利，南非，奥地利，挪威，葡萄牙，瑞典和丹麦的公司。

在填筑工程的高峰时，要求世界上最大的 18 艘挖泥船每天工作 24 h 连续工作 20 个月。

道路和公共基础设施的设计需要满足足够45 000 人(相当于一座新城镇)工作人口的需要。客运枢纽站设计每年旅客吞吐量 3 500 万人次。

## Section C 项目风险管理

**概述**

在韦氏词典中，风险被定义为伤害、损害或者损失的可能性。然而，这很显然是风险的一般定义。工程风险可描述为与工期、成本和质量三大主要约束条件有关的损失的可能性。

在工程项目中，成本、工期和质量三大目标中的每一个目标都有可能遭受风险和不确定性。因而断定，一个可行的报价应为根据经验和远见预测出的所有风险和不确定性确定适当的补偿费用。当这成为可能并且成本是可接受的，项目经理应该采取或提议措施，在风险发生之前消除风险，或者减少风险和不确定性的影响，如果它们发生，为它们预先采取措施。重要的是要认识到风险产生的根本原因，而且不要认为风险几乎是随机发生的事件。如果能识别出风险产生的根本原因，而且在产生不利的结果——风险发生前处理它们，通常风险是可以避免的。同时，他们应该确保剩余的风险以一定方式分配给项目参与各方，这样很可能产生最佳的项目业绩。

**工程风险**

建设项目包含着大量的风险，承包商负责承担这些风险，而业主则支付由此产生的费用。与其他行业相比，建筑业面临着更多的风险和不确定性。多年来，由于很多项目没有实现工期、成本和质量目标，建筑业在对付变化的不利影响方面有着非常差的声誉。变化不可消除，但是通过应用风险管理的原理，工程师可以改善这种变化的有效管理。

建设项目所面临的典型风险包括：

- 未能按规定的设计和建设工期完成；
- 在设计阶段未能按时获得总体规划、详细规划或建筑物规范/法规所要求的批准；
- 未预料到的不利地质条件导致项目延误；
- 异常的恶劣气候导致工期延误；
- 工人罢工；
- 未预料到的人工费和材料价格上涨；
- 项目完成后，未能租出；
- 现场操作事故导致人员受伤；
- 操作工艺低劣导致结构存在潜在的缺陷；
- 不可抗力(洪水、地震等)；
- 承包商对设计延误提出的索赔；
- 未能在业主的预算范围内完成项目；

**风险的成本**

对于一个组织而言，无论其对付风险与否，风险的成本对它的资产负债表都有重要的影响。风险管理本身的成本是由风险识别和风险评估，在适当的位置采取风险控制措施(如更好的安全防备，备用设备)，保险费用或者其他的财务支出，以及任何外聘咨询顾问佣金导致的成本所引起的。

这些确定的费用必须权衡发生风险时的成本。例如：

- 损失的直接成本——修理或替换毁坏的货物或资产，第三方赔偿。
- 损失产生的可测量间接成本——产量的损失或减少，对生产线的冲击作用，损失所带来的新职员的再培训，熟悉替换设备，事故调查成本，参与诉讼损失的管理时间以及增加的额外费用。
- 损失的间接成本——无能力履行合同，市场份额的损失，声誉的损失，劳资关系变差，工作士气变差，招募新职员问题，不利的压力关系。

**风险管理**

对于工程项目而言，由于项目趋于越来越复杂，竞争变得更加激烈，风险管理对于成功地完成工程任务以及保证施工过程竣工是至关重要的。由于施工工序需要资源的调整(例如，劳动力，材料和设备)完成一个预期的成本、进度、质量、安全目标，大量的可变性主要来源于诸如劳动生产率，地区工资水平，以及材料和设备成本及可获得性这些情况。不幸的是，许多承包商不熟悉这些风险因素，而且没有有效对付它们的经验和知识。因此，在建筑业竣工延期，成本超支和企业倒闭是很普遍的现象。

**风险管理的重要性**

当项目达到工期(计划/进度)，资金(估价)，质量，信息和组织目标时，风险管理为项目试图获得更好的控制提供了支持。做到这点需要运用创造性思维预先判断未来在项目中可能会发生的不利事件或者结果，为了阻止或减少这些事件的影响，以便提早制定采取行动的决策。风险管理是施工中决策过程的重要组成部分，现在被广泛的作为一种项目管理的重要工具。

风险管理可以：

- 在项目中促进活动不间断的前进，通过执行恰当的措施，在它们发生时尽可能快的消除任何障碍；
- 在项目，第三方以及项目团队中渗透信心；
- 促进项目内部的沟通；
- 支持项目的决策过程。

然而，我们运用风险管理设法预测未来。因此，它不是在风险发生之后对事件的判断。

**风险管理程序**

在分析风险管理四个重要步骤时，概率、频率、影响、重要性和揭示是必需的因素。这些步骤分别是风险识别，风险分析，风险应对，风险控制。

风险识别

在识别和排序项目的过程或者组成部分，它的主要目标以及风险时，需要付出大量的努力。识别步骤与下一个步骤风险分析是紧密相连的。为了提高有效性，风险识别需要大量的提前计划和研究工作。项目经理需要确定使用的分析技术，选择实施风险识别的主要人员，规定实施所需要的时间，而且决定在何处实施。为了研究风险，他们必须检查项目计划，采访相关人员，计算统计分析，以及审阅技术文件。

风险分析

项目经理运用一种选定的技术把风险识别阶段收集的数据转换成信息。共有两类风险分析技术：定量和定性技术。定量技术主要依靠统计方法，比如蒙特卡罗模拟。定性技术更多地依赖主观判断胜过适用统计计算，比如启发法。风险分析的目的是量化已识别出的风险对项目的影响程度。

图 18.1 比较了工程项目中风险事件发生的概率与它的影响程度。低影响程度的风险事件并不严重，可以划分为微小事件和期望事件。对于高影响程度和低概率的风险事件，它们一旦发生就是危险事件，但是由于其发生的可能性太低以至于不用考虑。然而，在项目管理过程中，具有高影响的风险事件是不能被忽略的，即使它们的概率很低。即使财务影响太大以至于不可预见费不能涵盖，在适当的时候应该使用备用计划和应对计划。运用风险管理去识别、评估和对付那些既有高影响又有高发生概率的事件。

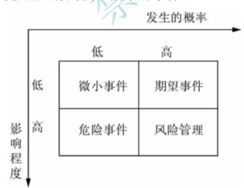



**图 18.1　风险源分类**

风险应对

风险应对是通过对项目风险的严重性进行评估做出的。为了减少与项目相关的风险的承担，业主和项目团队可以采取四种风险减轻策略：风险回避，风险减轻，风险转移，风险保留。

**风险回避**。如果判断出风险具有严重的后果，此时这种情形成为项目进行重新评价的依据。这需要重新考虑项目的目标，不是重新评价理念就是取消项目。

**风险减轻**。减轻风险包括重新设计项目，改变采购策略或者采取额外的地基勘察最小化地基的变化，变更规范或者合并不同的施工方法避免使用未经验证的施工技术。

**风险转移**。有四种常见的风险转移路径：

- 业主转移给承包商
- 承包商转移给分包商
- 业主、承包商、分包商或者设计单位转移给保险公司
- 承包商或者分包商转移给担保公司

如果风险可以被转移，风险后果可以被分担或者除了业主之外由某一方完全承担。业主将为此支付额外费用，因此采用这种风险应对形式是业主的责任。

**风险保留**。风险不是由可控制的一方保留就是由无法控制的一方保留。当控制成为可能时，可以尽力减少风险事件发生的可能性，同理，如果风险事件发生，可以最小化其影响程度。它必需包括在项目的不可预见费中。

风险控制

项目经理制定措施或者建立控制机构以减轻或者避免在施工过程中或者组成部分上的风险的影响。对于风险，项目经理可以采取两种方法中的任一种。他们对风险的反应是：看风险发展的形势变化，然后再采取任何行动。例如，他们在紧要关头雇佣更多的工人。或者，他们可提前采取行动：制定一套计划和成立一个机构。例如，他们建立早期预警系统，以发现和处理项目中的期望风险。

## Grammar：科技论文的写作(Ⅴ)——结语、致谢和参考文献

### Knowledge on Writing a Research Paper V—Conclusions, Acknowledgments and References

1. 结语(Conclusions)

无论涉及的内容如何不同，在论文中总要对所做的研究工作给出明确的意见和建议。这就是论文的结语或结论。论文的结语部分是对全文工作的总结，是论文的精华所在，是体现研究者的创造性之处，尤其值得重视。

论文的结语要求简明扼要，准确适当，抓住重点，突出特色。另外，在总结成果的同时，也可提及研究工作中的不足或需完善之处以及今后的研究方向。

撰写结语时，也可套用一些常用句型；但在多数情况下，是对成果的简洁描述。

(1) The research / The studies / The results / The investigation + Have (has) revealed / have (has) shown / have (has) demonstrated … / have (has) indicated / have (has) suggested

(2) It + Demands (much) further work / requires great deal of further research effort / calls for further study + in the field of

【例 1】 结语实例(与 Unit 3 摘要实例对照阅读)

SUMMARY AND CONCLUSIONS

Results from this investigation show that the yield-line method of analysis can be used to reliably predict the collapse load of simple-span and continuous-span composite bridges subjected to AASHTO truck loading. Comparison of results from the theoretical analysis to those from several tests on composite bridge models verifies the assumed yield-line failure patterns and substantiates the derived equations to estimate the ultimate collapse load. It is shown that the manner in which the transverse diaphragms are connected to the main longitudinal beams or girders will have a significant influence on the ultimate load-carrying capacity of relatively wide bridges. The derived equations can be used either to predict the ultimate load capacity or the required ultimate moments of resistance for design of a composite bridge.

**参考译文：**

结语：研究结果表明，屈服线分析方法可用来可靠地预测承受 AASHTO 车辆荷载的简支或连续结合桥的破坏荷载。通过理论分析结果与若干结合桥模型试验结果的比较，证实了所假定的屈服线失效模式以及所推导的估算极限破坏荷载的方程。研究表明，横隔板与纵向主梁的连接方式对相对较宽的桥梁的极限承载力有显著影响。所推导的方程可用来预测极限承载力，或用于结合桥极限抵抗弯矩的设计。

2. 致谢(Acknowledgments)

若研究项目得到某些组织机构的资助，或得到某些个人的支持和帮助，应在论文中(一般在结语部分之后)对这些团体和个人表示论文作者的谢意。一般可套用的语句结构有：

(1) The writers (authors) are thankful to…for…

(2) Results presented in this paper are achieved under the direction of…

(3) The presented work was (partially) supported by…, which is gratefully acknowledged.

(4) The financial support from…is gratefully acknowledged.

(5) This work was sponsored by…

3. 参考文献(References)

在论文中，凡是引用或参考他人文献的数据、资料、观点、方法和研究成果，都应该标明出处，对应地在参考文献中列出。参考文献的作用有两点：一是尊重他人的劳动成果，反映作者严谨的科学态度和作风；二是提供研究工作的科学依据，便于读者追根溯源，较全面

地了解前人的研究工作。

在正文中引用参考文献的标注方法一般采用顺序编号法，即在引用文献处文字的后面或右上角用方括号标注阿拉伯数字，正文引用的编号顺序与参考文献所列的编号顺序一致。

按照国际标准化组织 ISO690：1987 (Information and documentation Bibliographic references) 标准，参考文献的一般著录格式为：作者姓名，文献题名，出版事项(包括发表文献的书籍，刊物或论文集，出版日期，卷号，期号和起止页码等)。一般文献标题的第一个单词的首字母大写，也有一些杂志规定每个实词的首字母均大写。

对专利文献，其引用格式为：专利所有者，专利题名，专利国别，专利号，出版日期。

对 Internet 上的电子文献，其引用格式为：作者姓名，电子文献题名，电子文献的出处或可获得地址，发表或更新日期/引用日期。



# 附录 A　专业英语常用词缀

**附录 A1　常用前缀**

| 内　涵 | 词　缀 | 意　义 | 词　例 |
|---|---|---|---|
| 否定 | dis-, in-,<br>non-, un- | 不、无、非、未等 | disorder 无序的，inelastic 非弹性的，<br>unloaded 未加载的，uncertainty 不定性的 |
| | mal-, mis- | 不善，坏 | malfunction 故障，miscalculate 算错 |
| | de-, dis-, un- | 去，解，消除 | decentralize 分散，disconnect 分离，unloading 卸载 |
| | anti-，contra-,<br>counter- | 反、逆、对抗 | antirusting 防锈的，contraflexure 反向挠曲<br>counterbalance 抗衡 |
| 空间位置和方向 | extra- | 外，向外 | extraneous 外加的，extrapolate 外推 |
| | in- | 内，向内 | incurve 内弯，inclination 倾向 |
| | infra- | 在下，在下部 | infrastructure 基础，基础设施 |
| | inter- | 在……间，相互 | interrelate 相互有关，interdepend 相互依赖 |
| | intra- | 在内，内部 | intramural 城市内的，intranet 局域网 |
| | mid- | 中，间 | midposition 中间位置，midsection 中间截面 |
| | out- | 外，向外，出 | outline 轮廓，outward 向外的 |
| | over- | 在上面，在外 | overground 地上的，overlook 前进 |
| | pre-,pro- | 向前，在前 | preface 序言，proceed 远眺 |
| | sub-,under- | 下，在下面 | subway 地下铁道，underground 底下的 |
| | super-,sur- | 在……上 | superstructure 上部结构，surface 表面 |
| 时间次序 | fore- | 预先，先前 | foreshock 前震，forecast 预报 |
| | post- | 后，次 | posttensioned 后张的，postgraduate 研究生 |
| | pre- | 事先 | prestress 预应力，precaution 预防 |
| | re- | 再，重现 | renew 更新，readjustment 再调整 |
| 比较程度 | extra- | 格外，超越 | extraordinary 非常的，extra-light 特轻的 |
| | hyper- | 超过，极度 | hypersonic 超声的，hyperplane 超平面 |
| | over- | 超过，过度 | overload 超载，overmix 拌合过度 |
| 共同相等 | co- | 共同，和 | coexist 共存，cooperation 合作 |
| | equi- | 同等 | equilibrium 平衡，equivalent 等价的 |
| | sym-, syn- | 同，共 | symmetry 对称，synchronous 同步的 |
| 通过遍及 | dia- | 通过，横过 | diameter 直径，diagonal 对角线 |
| | trans- | 横过，贯通 | transport 运输，transparent 透明的 |
| 数量 | deca-,deci- | 十，十分之一 | decameter 10 米，decigram 分克 |
| | hecto-,centi- | 百，百分之一 | hectoliter100 升，centimeter 厘米 |
| | kilo-,milli- | 千，千分之一 | kilogram 千克，millimeter 毫米 |
| | maga-,micro- | 兆，微（百万分之一） | megacycle 兆周，microampere 微安培 |
| | multi- | 许多，多数 | multimeter 万用表，multilateral 多边的 |
| | hemi-,semi- | 半，一半 | hemicycle 半圆，semiconductor 半导体 |
| 其他 | macro-,magni- | 长，大，宏大，巨大 | macroseism 强震，magnification 放大 |
| | micro- | 微小，小型 | microphone 显微镜，microwave 微波 |
| | ortho- | 直，正，垂直 | orthogon 矩形，orthograph 正视图 |

附表 A2　常用后缀

| 内涵 | 词　缀 | 意　义 | 词　例 |
|---|---|---|---|
| 名词 | -er | ……者(人或物) | observer 观察者，computer 计算机 |
| | -ician | ……家……能手 | technician 技师，mechanician 机械师 |
| | -ist | 从事……者 | scientist 科学家，chemist 化学家 |
| | -or | ……者(人或物) | operator 操作者，censor 传感器 |
| | -acy | 性质、状态等 | accuracy 精密，determinacy 确定性 |
| | -age | 状态、行为等 | storage 储存，voltage 电压 |
| | -al | 动作、过程等 | approval 赞许，removal 移去 |
| | -ance，-ence | 性质、状态、行为、过程等 | resistance 抵抗，difference 差别 |
| | -ancy，-ency | 性质、状态、行为、过程等 | constancy 恒定，efficiency 效率 |
| | -bility | 动作、性质、状态等 | reliability 可靠性，possibility 可能性 |
| | -ety | 性质、状态等 | variety 变化，dubiety 怀疑 |
| | -faction，-facture | 做成，……化，作用等 | liquefaction 液化，manufacture 手工制造 |
| | -fication | 做成，……化 | amplification 放大，simplification 简化 |
| | -ine | 表示抽象概念 | discipline 学科，machine 机器 |
| | -ing | 动作的过程、结果、对象等 | reading 读数，building 建筑 |
| | -ion，-sion，-tion，<br>-ation，-ition | 行为的过程、结果、状况等 | action 作用，conclusion 结论，production 生产，<br>specification 规范，composition 组成 |
| | -ment | 性质、状态、过程、手段等 | movement 运动，treatment 处理 |
| | -ness | 性质、状态、程度等 | hardness 硬度，slenderness 柔性 |
| | -ship | 情况、状态、性质、技巧等 | scholarship 学识，relationship 关系 |
| | -th | 动作、过程、性质、状态 | width 宽度，growth 增长 |
| | -tude | 性质、状态、程度 | magnitude 量值，latitude 纬度 |
| | -ure | 行为、结果 | fracture 断裂，pressure 压力 |
| | -graphy | ……学、写法等 | petrography 岩石学，bibliography 书目 |
| | -ics | ……学，……法 | dynamics 动力学，bionics 仿生学 |
| | -logy | ……学，……论 | geology 地质学，hydrology 水文学 |
| | -ant，-ent | 产生的物品或物质 | Resultant 产物，solvent 溶剂 |
| 形容词 | -able，-ible | 可能的，可以的 | applicable 能应用的，permissible 容许的 |
| | -al | ……的 | lateral 横向的，additional 附加的 |
| | -ant，-ent | ……的 | important 重要的，dependent 依赖的 |
| | -ar | ……形状的，……特性的 | regular 有规则的，linear 线性的 |
| | -ary | 属于……的，与……有关的 | contrary 相反的，elementary 基本的 |
| | -ive | 属于……特性的，与……有关的 | substantive 本质的，decisive 决定性的 |
| | -ory | 属于……的，……性质的 | preparatory 预备的，compulsory 强制的 |
| | -ful | 充满的，引起……的 | plentiful 充足的，useful 有用的 |

续表

| 内涵 | 词　缀 | 意　义 | 词　例 |
|---|---|---|---|
| 形容词 | -ous | 充满……的 | continuous 连续的，porous 多孔的 |
| | -en | 由……制的，……质的 | wooden 木制的，earthen 泥土的 |
| | -ble，-ple | ……倍的 | double 两倍的，quadruple 四倍的 |
| | -fold | 倍数 | twofold 两倍的，manifold 多倍的 |
| | -most | 最……的 | utmost 极度的，topmost 最上的 |
| | -less | 没有……的，无……的 | wireless 无线的，stainless 不锈的 |
| | -ic，-atic，-ical | 属于……的，与……有关的 | metallic 金属的，systematic 系统的 |
| 动词 | -en | 使成为，引起 | harden 硬化，strengthen 加强 |
| | -fy | 致使，使成为 | verify 证实，classify 分类 |
| | -ize(ise) | 变成，……化 | realize 实现，standardize 使……标准化 |
| 副词 | -ly | 状态，程度 | relatively 相对地，comparatively 比较地 |
| | -ward(s) | 方向 | onwards 向前，upwards 向上 |
| | -ways | 方向，方式 | endways 竖立，sideways 向一边 |
| | -wise | 方向，方式 | endwise 侧着，lengthwise 顺着 |

# 附录 B 土木工程中常用的度量衡和单位换算

| 名 称 | The Metric System | | GB &US System 英美制 | |
|---|---|---|---|---|
| | 英、中文名称 | 简写 | 英中文名称及换算 | 简写及换算 |
| 长度<br>Length | 1 centimeter (厘米) | cm | 0.397 inch(英寸) | 1 in = 2.54 cm |
| | 1 meter (米) | m | 3.2808 feet(英尺)<br>1.0936 yard(码) | 1 ft = 0.3048 m<br>1 yd = 0.9144 m |
| | 1 kilometer (千米) | km | 0.6214 mile(英里) | 1 mi = 1.6093 km |
| 面积<br>Area | 1 square millimeter(平方毫米) | $mm^2$ | 0.00155 square inch<br>(平方英寸) | 1 sq.in. =645.16 $mm^2$ |
| | 1 square meter (平方米) | $m^2$ | 10.7643 square feet<br>(平方英尺)<br>1.196 square yards<br>(平方码) | 1 sq.ft. = 0.0929 $m^2$<br>1 sq.yd. = 0.836 $m^2$ |
| | 1 square kilometer(平方千米) | $km^2$ | 0.3816 square miles<br>(平方英里) | 1 sq.mi.= 2.59 $km^2$ |
| 体积<br>Volume | 1 cube meter(立方米) | $m^3$ | 35.3357 cub feet<br>(立方英尺)<br>1.308 cub yards(立方码) | 1 cu.ft.=0.0283 $m^3$<br>1 cu.yd.=0.7645 $m^3$ |
| 重量，<br>力<br>Weight,<br>Force | 1 kilogram(千克) | kg<br>(kgf) | 2.2046 pounds(磅) | 1 lb(lbf)=0.4536kg |
| | 1 ton(吨) | t(tf) | 0.9842 long tons(英吨)<br>1.1025 short tons(美吨)<br>9.8076 kN(千牛) | 1 long ton=1.106tf<br>1 long ton=9.946kN<br>1 short ton=0.907tf<br>1 short ton=8.896kN |
| | 1 Newton(牛)<br>（国际单位） | N | 0.2248 pounds(磅) | 1 lb(lbf)=4.4482 N<br>1 N=0.102 kgf<br>1 kgf=9.8066N |
| | 1 kilo Newton(千牛) | kN | 0.2248 kips(千磅) | 1 tip=4.4482kN |
| 速度<br>Velocity | 1 meter/second(米/秒) | m/s | 2.2369miles/hour<br>(英里/小时) | 1 mi/h=0.447m/s |
| | 1 kilometer/hour<br>（千米/小时） | km/h | 0.6214 miles/hour<br>(英里/小时) | 1 mi/h=1.6093km/h |
| 压强，<br>应力<br>Pressure,<br>Stress | 1Newton per square meter<br>(牛顿/平方米) | $N/m^2$ | 0.000145 pounds per square inch<br>(磅/英寸 $^2$) | 1 psi=6894.76$N/m^2$ |
| | 1 million Newton per Square meter(兆帕) | MPa | 0.145 kilo pounds per square inch<br>(千磅/英寸 $^2$) | 1 ksi=6.895MPa<br>1MPa=10.204$kgf/cm^2$ |
| 线集度<br>Linera<br>Load | 1kip/ft=1488.16kgf/m=14.59kN/m<br>1 ton/m=0.672kip/ft<br>1kN/m=0.0685 kip/ft | | | |

# 附录 C　土木工程网址及信息检索

## 1. 协会和组织 (Association or Institute)

AAEE (American Academy of Environmental Engineers)
http://www.aaee.net/
AAR (Association of American Railroads)
http://www.aar.com/
AASHTO (American Association of State Highway and Transportation Officials)
http://www.transportation.org/
ABCD (Association for Bridge Construction and Design)
http://abcdpittsburgh.org/
ACE (American Council of Engineering Companies), UK
http://www.acenet.co.uk/
ACEC (American Council of Engineering Companies)
http://www.acec.org/
ACI (American Concrete Institute)
http://www.aci-int.org/
AIA (American Institute of Architects)
http://www.aia.org/
AISC (American Institute of Steel Construction)
http://www.aisc.org/
ANSI (American National Standards Institute)
http://www.ansi.org/
AREMA (American Railway Engineering and Maintenance of Way Association)
http://www.arema.org/
ARTBA (American Road & Transportation Builders Association)
http://www.artba.org/
ASBI (American Segmental Bridge Institute)
http://www.asbi-assoc.org/
ASCE (Association of State Dam Safety Officials)
http://www.asce.org/
ASDSO (Association of State Dam Safety Officials)
http://www.damsafety.org/
ASEE (American Society for Engineering Education)
http://www.asee.org/
ASNT (American Society for Nondestructive Testing)
http://www.asnt.org/

ASPRS (American Society for Photogrammetry and Remote Sensing)
http://www.asprs.org/
ASQC (American Society for Quality)
http://www.asq.org/
ASTM (American Society for Testing & Materials)
http://www.astm.org/
BCA (British Cement Association)
http://www.bca.org.uk/
BIA (Brick Industry Association)
http://www.brickinfo.org/
BRANZ (Building Research Association of New Zealand)
http://www.buildingresearch.org.nz/
BRI (Building Research Institute), Japan
http://www.kenken.go.jp/
BSI (British Standards Institution)
http://www.bsi.org.uk/
CAEE (Canadian Association for Earthquake Engineering)
http://caee.carleton.ca/caee/
CERF (Civil Engineering Research Foundation)
http://www.cerf.org/
CIB (International Council for Research and Innovation in Building and Construction)
http://www.cibworld.nl/
CRSI (Concrete Reinforcing Steel Institute)
http://www.crsi.org/
CSCE (Canadian Society for Civil Engineering)
http://www.csce.ca/
CSI (Construction Specifications Institute)
http://www.csinet.org/
FIDIC (International Federation of Consulting Engineers)
http://www.fidic.org/
IABSE (International Association for Bridge and Structure Engineering)
http://www.iabse.ethz.ch/
IACES (International Association of Civil Engineering Studengs)
http://www.iaces.org/
ICE (Institute of Civil Engineers)
http://www.ice.org.uk/
IMI (International Masonry Institute)
http://www.imiweb.org/
IRF (International Road Federation)
http://www.infnet.org/

ISE (The Institution of Structural Engineers)
http://www.istructe.org.uk/
ISO (International Organization for Standardization)
http://www.iso.ch/
JASBC (Japan Association of Steel Bridge Construction)
http://www.jasbc.or.jp/english/
JSCE (Japan Society of Civil Engineers)
http://www.jsce.or.jp/English/
NABIE (National Academy of Building Inspection Engineers)
http://www.nabie.orzg/
NISC (National Information Services Corporation)
http://www.nisc.com/
NAS (National Academic of Science)
http://www.nationalacademies.org/
NSSN (National Standards Systems Network)
http://www.nssn.org/
PCA (Portland Cement Association)
http://www.portcement.org/
PCI (Precast/Prestressed Concrete Institute)
http://www.pci.org/
PCA (Portland Cement Association), USA
http://www.cement.org/
RILEM (International Union of Testing and Research Laboratories for Materials and Structures)
http://www.rilem.cog/
SBI (Swedish Institute of Steel Construction)
http://www.sbi.se/
SEAOC (Structual Engineers Association of California)
http://www.seaoc.org/
WIPO (World Intellectual Property Organization)
http://www.wipo.int/

## 2. 信息检索 (Information Searching)

ACSM (American Congress on Surveying and Mapping)
http://www.landsurcryor.com.acsm
ASCE Publications
http://www.pubs.asce.org/pubshoml.html
Derwent Publication Ltd.
http://www.derwent.com/
Engineering Index

http://www.ei.org

ENGnetBASE

http://www.engnetbase.com

International Database and Gallery of Structures

http://www.structurae.de/

ISI (Institute of Scientific Information)

http://www.isinet.com/

NISC (National Information Services Corporation)

http://www.nisc.com/

Publist.com

http://www.publist.com

The InterNIC Directory of Dictionaries

http://ds.internic.net/

UMI (University Microfilms International)

http://www.umi.com

## 3. 政府部门 (Government)

EPA (Environmental Protection Agency)

http://www.epa.gov/

FHWA (Federal Highway Administration)

http://www.fhwa.dot..gov/

Library of Congress

http://lcweb.loc.gov/

NIST (National Institute of Standards and Technology)

http://www.nist.gov/

NSF (National Science Foundation)

http://www.nsf.gov/

NTIS (National Technical Information Service)

http://www.ntis.gov/

Office of Highway Information Management

http://ctil.volpe.dot.gov/ohim/

U.S.Department of Transportation

http://www.dot.gov/

U.S.Geological Survey Home Page

http://www.usgs.gov

United States Geological Survey

http://info.er.usgs.gov/USGSHome.html

USPTO (United States Patent & Trademark Office)

http://www.uspto.gov/

Water Management Research Laboratory

http://asset.arsusda.gov/wmrl.html

## 4. 在线期刊和网络书店 (Journal and Bookstore online)

Barnesandnoble
 http://www.barnesandnoble.com/
Edward Arnold
 http://www.arnoldpublishers.com
Elsevier Science
 http://www.elsevier.com/
Engineering Press Bookstore
 http://www.engrpress.com/
John Wiley & Sons
 http://www.wiley.com
McGraw-Hill
 http://www.mcgraw-hill.com/
Prentice Hall
 http://www.prenhall.com
Springer-Verlag
 http://www.springer.de/
Thomas Telford
 http://www.t-telford.co.uk/

# 习题参考答案

## Chapter 1　习题参考答案

### Section A

Ⅰ.

lateral;　static;　earthquake;　equivalent;　dynamic

Ⅱ.

人类的主要需求之一是由土木工程师提供的。土木工程师设计并建造房屋、铁路、道路、桥梁、隧道、港口、给水和污水系统以及其他公共设备。供水及灌溉系统的合理设计会提高一个地区粮食的产量。除了仅仅作为住处之外，由土木工程师建造的住处提供了一个和平而舒适的生活。

### Section B

Ⅰ.

1. fluid mechanics
2. water and sewage system
3. stability of slopes and fills
4. intensity and duration
5. control water runoff
6. 安全系数
7. 强度和刚度
8. 积极的招聘
9. 理论应用于实践
10. 浇注和养护

Ⅱ.

designer;　forces;　effects;　deflection;　distribution

### Section C

Ⅰ.

1. F　2. T　3. F　4. F　5. T

Ⅱ.

现在建筑师选定了结构体系和建筑材料，他考虑了结构体系中荷载的传递以及这种传递对材料的影响。这样，他就可以提供足够的材料。换句话说，他所设计的结构中所有尺寸合理的构件能够确保产生的内应力不会超过所涉及的材料的容许应力。

## Chapter 2　习题参考答案

### Section A

Ⅰ.

deformation;　tensile;　reduction;　elongation;　brittle

Ⅱ.

很难获得比例极限的精确值，尤其是应力应变图由直线向曲线过渡的时候。因此，需要采用其他应力作为实际的弹性极限。对于特定变形时总是采用屈服点和屈服强度。

Section B

Ⅰ.

internal; external; counteracted; prestress; reinforcement

Ⅱ.

高层建筑的竖向构件从上到下逐层对累积的重力荷载进行传递，这就需要有较大尺寸的墙体或柱体来承担荷载。同时，这些构件还要将风荷载及地震荷载等侧向荷载传给基础，但是更重要的是侧向力产生的倾覆力矩和剪切变形要大得多，必须谨慎设计来保证。

Section C

Ⅰ.

1. T 2. F 3. F 4. T 5. F

Ⅱ.

结构钢的塑性可以定义为允许产生大的变形而不会破坏的性能，它是能够抵抗突然破坏的一种能力，是钢材最重要的一项性能。结构钢设计的许多简化假定之所以合理就是因为钢的塑性。

## Chapter 3 习题参考答案

Section A

Ⅰ.

1. as; quantity; to; into; cement
2. age; hardening; for; of; plastic state; into; decorative
3. electrical; thermal; metallic; of

Ⅱ.

目前的趋势是开发轻质量的材料。在全国各地，轻骨料混凝土迅速地发展起来了。轻骨料混凝土主要被用来保温隔热，例如在住宅里。在冬天可以保温而在气候炎热时可以低成本制冷。在住宅中，轻骨料混凝土的相对弱点对墙是不重要的，但是其对屋面板、楼板和梁却很重要。

纤维掺入混凝土中，能明显地改善混凝土的抗冲击性能、抗疲劳性能和抗震性能。纤维能抑制混凝土早期裂缝，同时也提高抗折强度或是断裂模量。纤维增强混凝土已经被用在路面上，混凝土的抗折强度和抗冲击强度对路面来说都是很重要的。纤维混凝土也给未来水泥基复合材料提供了一个发展趋向。

Section B

Ⅰ.

1. of
2. concrete; steel; alkaline chemical; acid; corrosion; spalling; deicing chemicals

Ⅱ.

水泥水化后，会形成大量的钙矾石。当混凝土凝固，强度开始发展时，如果有足够数量的养护水存在的情况下，混凝土将会黏结钢筋，同时开始膨胀。既然钢筋和混凝土粘结在一起，后期，在钢筋的抑制作用下混凝土膨胀将会产生拉力，然而混凝土本身也受压。在潮湿养护的最后，当构件被暴露在干燥的条件下，将会像普通硅酸盐水泥混凝土一样产生收缩。

最常见的钢筋类型（区别与预应力钢筋）在形式上是圆形，通常被称为钢筋，普遍应用的钢筋直径范围是 10～35 mm，有时也用大直径 44 mm 和 57 mm。这些钢筋被做成表面有变形的，其目的是增强钢筋和混凝土之间的抗滑移性能。对于这些变形的最小规定（如间隔、投影）已经通过科学实验研发出来了。不同的钢筋生产者使用不同的形式，所有这些形式都是为了满足需求。

Section C

Ⅰ.

1. include; to; weathering; chemical actions; wear
2. water-cement ratio; Permeability; cement; porosity; permeability
3. impermeable; permeability; proportions; placing; compaction; curing

Ⅱ.

对于结构工程师，需要理解结构的可靠性理论，并将其应用到设计、施工中，对那些有重大失效后果的特殊结构中，无论直接地应用还是间接地通过规范使用，其目的都是经济性和适当安全性的综合考虑。这个课题正充分地被发展，并作为能够达到本科和研究生水平的土木和结构工程师的正式培训教材的一部分了。一些大学数年来一直研究混凝土的结构安全性。

水化水泥浆的强度和渗透性是与由水灰比和水化程度来控制的毛细管孔隙相联系的。通常，除了耐冻融作用，混凝土耐久性主要是通过渗透性来控制的，这就不难理解为什么混凝土强度和耐久性有着直接的联系。因此，在例行的配合比设计中，仅仅强调和易性和强度，而忽略了混凝土的耐久性，除非暴露在特殊环境下才会考虑耐久性。

## Chapter 4　习题参考答案

Section A

Ⅰ.

1. branch; applied mechanics; with; to; loading
2. of; stresses; strains; deflections; by
3. For; within; linear elastic range; loads

Ⅱ.

对于解决一些特定的问题，叠加法被认为是更好的方法。然而，熟悉叠加法比解决这个问题本身更重要，因为叠加法可应用在应力分析的很多领域，而且在我们今后的研究中还会经常应用。

当研究材料力学时，你会发现，你的努力自然分为两部分：第一，理解概念的逻辑发展，第二，把这些概念用于实际。前者是通过研究、推导、讨论和举例，后者是解决问题。一些例子和问题是数值的特点，其他是代数（或符号的）性质的 。

Section B

Ⅰ.

1. applying; to; load; deformation
2. from; stress; strain; stresses; strains
3. on; ultimate tensile; compressive; shearing strength

Ⅱ.

在这些情况下，我们知道，应力是二维的或者可能是双轴的，还有三维或三轴的一些其

他情况。对于受到一个双轴或三轴应力的结构来说，我们该如何检查设计的安全呢？最明显的办法是进行试验，试验中的试样会像实际结构一样，在同样的多轴应力方式下失效；然后，允许的多轴应力利用足够的安全系数来确定。然而，在设计中，对于每一组的新的多轴应力都要求一组试验。

在各种不同的失效理论发展过程中，我们不能避免三维的影响，只是我们在其中一个应力为零的情况下，能够避免理论上三维问题的复杂性。这不是一个严格的限制，因为在工程实际中大部分问题可归结为设计的双轴应力状态。当剪应力与伴随正应力发生时，主要应力就被确定了。因此，出于实用的目的，我们需要考虑在受到两个非零正应力而第三个正应力为零的材料的失效。

Section C

Ⅰ.

1. from; concentric; eccentric; of
2. due to; prestressed concrete
3. Prestressed; in comparison with

Ⅱ.

在预制和预应力混凝土的工业中，高强混凝土的使用导致模具的快速循环、生产效率的提高以及在处理和运输过程中的损失减小。因为其渗透率非常低，高强度混凝土用于那些由于磨损、腐蚀和各种化学腐蚀对混凝土的耐久性产生不利影响的环境中。

在普通的钢筋混凝土中，经济优势不像在预应力混凝土中那么明显。大多数例子中，预应力的精确计算来自于结构的自重，因此，自重减少 25%就会使预应力钢筋的重量有大幅度的减少。混凝土重量减少的另一个优点是受剪构件对地震荷载抵抗作用加强，因为地震作用是结构自重的直接函数。



## Chapter 5 习题参考答案

Section A

Ⅰ.

loads; soil; compression; failure; progressive

Ⅱ.

1. elastic-plastic design method
2. stress-strain curve
3. space structure
4. ductility and impact resistance
5. brittle fracture
6. 热膨胀系数
7. 双层网格
8. 残余应力和变形
9. 屈服强度与极限强度
10. 化学成分

Section B

Ⅰ.

suitable; overall; relationship; structural; properties

Ⅱ.

过去几年中，对诸如钢筋混凝土和结构钢这样的建筑材料的研究取得了巨大进步，对于这些材料的有效利用也拓宽了视野。结构工程师和建筑师也遇到了挑战，就是要找到有效而

经济的新的结构形式用于不同的建筑范围和高度甚至是对于超过 100 层的建筑物。

### Section C

Ⅰ.

1. the law of equilibrium
2. foundation settlement
3. wind tunnel test
4. average population density
5. earthquake and tsunamis
6. 作用线和力的指向
7. 荷载作用与传递机理
8. 直角坐标轴
9. 恒载和活载
10. 强度和稳定性准则

Ⅱ.

1. F　2. F　3. F　4. T　5. T

## Chapter 6　习题参考答案

### Section A

Ⅰ.

1. to;　great;　between
2. of;　from;　to;　of;　without
3. deposited;　segregation;　air pockets;　placed

Ⅱ.

混凝土施工有很多环节，它包括骨料场、搅拌站、运送罐车和混凝土泵等。每个过程都像一条链中的一个环节，所以各个环节之中的协调是很重要的。

其他的问题是选择电气与机械设备和具体设计混凝土原料加工与搅拌厂以及压缩空气、配水、配电系统。



### Section B

Ⅰ.

1. in;　of;　during;　of
2. sheaves;　pulleys;　winches;　hoists;　derricks;　cranes
3. winches;　hoists;　trolleys;　crane

Ⅱ.

铲运机可以是自驱动的或是由牵引机拖动，它有刀形刮片，能切除一层表土并收集到内部的拖斗中，并能一次挖掘 1400 $ft^3$（40 $m^3$）土方并运到附近的地点倾倒。

桥式起重机有一根箱形梁（叫行车梁），梁的两端运行在高架轨道上。行车能够沿着轨道前后运动。起重系统装在沿着行车移动的滑车里，桥式起重机经常安装在需要吊运的钢梁和木料堆的上方。

### Section C

Ⅰ.

1. where;　where
2. versatile;　tiers;　frames;　stacked
3. on;　on

Ⅱ.

脚手架只准由经过批准并取得资格的胜任人员安装和拆卸。必须使用合适的设备来安全提升脚手架的配件、支柱和板材。提升设备的结构必须能够避免被提升物绊住或绳结打滑致使脚手架倾斜的可能。严禁使用抛和丢的设备。

无论何时，脚手架都必须安装在牢固的地面上并且必须使用基础板。脚手架的地脚或固定地必须稳固，能够在承载预期最大负载的情况下不发生沉降或位移。不得用桶、箱、散砖或混凝土块之类的不稳定物体支撑脚手架。

## Chapter 7　习题参考答案

### Section A

Ⅰ.

1. with;　recreation;　boating;　swimming;　water skiing
2. consists of;　upstream;　downstream
3. footing;　at;　dam;　erode

Ⅱ.

出于经济方面的考虑，建坝所需的材料在坝附近是很有必要的。对于混凝土坝，如果大量的自然材料或良好的可用岩石作为骨料，是我们所希望的。如果附近有可用的石灰石，则可以部分或全部取代硅酸盐水泥。

储存在上游的水对大坝产生了主要的力。此外，水可能渗透到坝体甚至大坝的基础。这将导致大坝隆起而影响到坝的稳定性。还有波压力、冰压力、地震时产生的压力等也会影响坝的稳定性。上述情况中，由于地震产生的压力很大，这一直是几个大坝产生严重裂缝的主要原因。

大坝高度的定义不同，如在道路之间的不同海拔或泄漏嵴和发掘的基础得最低。但是，大坝高度援引的数字往往是以其他方式确定。常见的高度是采取旧河床以上的大坝的净高度。



### Section B

Ⅰ.

1. hydraulic structures;　subgrade;　shallow;　geology;　engineer
2. water flow;　level;　amount;　speed;　ice;　silt;　sea level;　wave actions; hydrology; hydraulic

Ⅱ.

在古代，人们已经就开始试着利用河流来满足他们日常生活的需求，河流能够提供给他们饮用水及灌溉的用水，而且河流船运是最经济的运输方式。河流也被用来作为阻止敌人袭击的防御线。由此涉及的技术一代一代的流传下来，最终形成了科学的一个分支。

影响土壤侵蚀的主要因素包括降水，风，温度变化，表面坡度，土壤的特征及植被覆盖率。在农业和森林方面，防止土壤侵蚀所采用的措施包括增加土壤的有机物含量，作物轮换，改进农耕方法，加大植被的覆盖，种植等高植物，条带植物，及植树造林。

### Section C

Ⅰ.

1. fundamental;　between;　water;　water pressure;　slipping;　stability;　weight
2. drinking;　irrigation;　defending;　from;　to

Ⅱ.

海运港口能够为船只、货船提供停泊、货物储存服务。当码头专门供旅客上船、下船和小件货物转运，即称为旅客码头；当货运成为主要业务时，码头即水运、货运码头。当主要存储和装卸铁矿石、石油、石油和粮食时，码头即为大宗货运码头。

停泊结构是船只可以安全停泊的地方，其分类为：垂直型和敞开型结构。垂直型结构用片状、打板桩、块状墙沉箱建成。而且可以根据所处理的货物类型分类。例如深海外的钦奈港口分别贮存油、矿石、集装箱，有油轮停泊处和集装箱停泊处。

## Chapter 8　习题参考答案

### Section A

Ⅰ.

1. marshalling;　conception
2. Prestress;　tension
3. suspension
4. parabolic;　catenary
5. deck

Ⅱ.

由于运输和安装大而重的构件会遇到许多问题，预制梁的跨径不可能超出 120 ft 很多。另一方面，桥梁有采用较大跨径的明显倾向。通过取消中央桥墩和使边墩从分隔行驶的公路的边缘向外移出可以改善公路的安全。对于城市内的高架快速公路，大跨径可以简化引道，并且使桥下活动的障碍物减至最少。出自对损坏周围环境的担心，也促使选用大跨径来建造连续的高架桥。对于跨河桥梁，由于通航宽度的要求，多半不能设置中间桥墩。

拱桥有 1000 多年历史的传统样式桥梁，最初是用石头铺成的路以便马和大车通过，后来才用于机动车通行的路。新中国成立后，拱形经常使用在铁道线上。在成都到重庆的铁道线上有 324 个普通型和小型的石拱桥。而在宝鸡到成都线上，仅从黄沙河到成都段就有 175 个拱桥。在技术上对传统样式进行更新后，新的拱形桥具有更大的跨距和承载力。



### Section B

Ⅰ.

1. pier;　wing
2. cellular;　hammerhead
3. end;　intermediate
4. bent;　columns

Ⅱ.

桥梁的下部结构一般包括桥台（一般在桥两端）和桥墩（在桥台之间）。桥墩和桥台通常建在单独施工的基础之上，基础的种类包括扩大基础和桩基础，基础是下部结构的一部分。桥台有两个主要作用，它既能支撑桥跨结构的端部，又为衔接桥梁的路堤填土或石料提供一些横向支撑力，因此桥台起着桥墩与挡土墙共同所起的作用。对于典型的钢筋混凝土桥台，由于没有延伸胸墙基础来做支撑，翼墙处于悬臂状态，这一点对圬工桥台是很有必要的。翼墙底面边缘设置斜坡的目的是使这个底边低于路堤的挡土墙的底面。

桥梁墩身顶部的尺寸取决于实际条件，如桥梁支座反力的严重程度、需要提供扩大的上部结构的距离，以及桁架或梁之间的距离。如果墩身延伸时通过水体，它的形状有可能由水位决定，以防止涡流和冲刷。

Section C

Ⅰ.

1. geometry; structure; vertical
2. deterioration
3. stronger; durable
4. chloride
5. corrosion

Ⅱ.

不适当的桥梁扶手的更换，朝向迎面车流的护墙和扶手端的改动，以及在下承式梁或桁架端部，结构上分道区内或恢复区（自桥面端部起 9m）支柱前用缓冲器作保护，这些都是桥梁修复计划中须要考虑的措施。

在有些情况下，对破损严重的桥面可先采取临时补块和修补坑洞等措施，直到钢筋受到腐蚀或者混凝土破损致使正常荷载通过结构物而不安全时，再作彻底处理。

脱盐这种方法可用来停止由氯化物引起的腐蚀，它通过电磁场将氯离子游离到外面的正极并远离钢筋，这一过程需要 6 个星期。重新碱化是将钠离子从外部阴极引入到混凝土中，因此它能停止由碳酸化引起的腐蚀。由于电磁场的作用，钠离子与在钢筋上产生的氢离子结合，这样碱度提高到刚能被再次钝化的水平。即便所有碳化的混凝土和被氯化物污染的混凝土本身是完好的，也可以采用混凝土置换的方法停止腐蚀，虽然，这需要换掉所有受污染的混凝土。



## Chapter 9 习题参考答案

Section A

Ⅰ.

1. beam; joist; girder; column; post; stay
2. which; as; by
3. with; by; as

Ⅱ.

通常情况下，分析的标准程序是考虑建筑物的线弹性行为。然而，分析抗震建筑物避免倒塌时，必须考虑非弹性和非线性动力行为。

虽然大多数结构按照线弹性特征进行分析，但是如果在地震作用下结构处于极限荷载状况，此时，需要考虑材料非线性行为和作用在结构上的荷载变化产生的非线性几何变形。

Section B

Ⅰ.

1. within; with
2. to; which; on
3. from; on; to

Ⅱ.

因此，他们都试图用计算机的巨大存储能力、快速处理速度及用户友好的交互图形能力，来自动完成并紧密联系其他繁重的和单独的工程或生产任务，从而减少产品开发和生产的时间和成本。

即综合子过程的结果是各个产品部件间的关系以草图或布局图的形式来表示的所期望产品的概念设计。

### Section C

Ⅰ.

1. As;　for;　by
2. solution;　accuracy;　unknown

Ⅱ.

采用有限单元法求解物理问题，无论是结构问题、热传导问题、流体或其他一些问题，都有一些特定的步骤。

许多这样的问题必须在我们接受有限元计算结果之前提出并进行核实。

## Chapter 10　习题参考答案

### Section A

Ⅰ.

1. in;　of;　and
2. on;　with;　to
3. general;　local;　punching

Ⅱ.

因为可以通过碾压、夯实、振捣或其他方法压实土以增加其密度和提高其承载强度，所以可压缩性是土的一个重要特征。

黏性土往往由于空隙浸水饱和而不可压缩，因此，只有在空隙水流出后，土颗粒的下沉才能使黏性土具有可压缩性。

### Section B

Ⅰ.

1. because;　for;　of;　by;　above
2. onto;　for;　within

Ⅱ.

在土壤沉降处设计多层建筑基础的主要问题，就是要使建筑物的总沉降量保持在合理的限度内，而且特别要注意相邻柱子之间的相对沉降量不能过大。

在实践中极限平衡法被用于边坡稳定分析当中。它假定破坏面是发生在沿着一个假想或已知破坏面的点上的。土的有效抗剪强度与保持极限平衡状态所要求的抗剪强度相比，就可以得到沿着破坏面上的平均安全系数。

Section C

Ⅰ.

1. which;　of;　avoiding

2. close;　reduces　soil

3. so;　required

Ⅱ.

三种现代采用的打桩方法是：打入桩，将预制桩打入基岩中以提供坚固的基座；沉管灌注桩，用振动锤将钢管打入地下，在钢管里放入钢筋并在浇筑完混凝土后拔出钢管；钻孔灌注桩，先进行钻孔再将混凝土直接浇入桩孔中。

基础的尺寸是由可能施加在基础底部的荷载除以地基土和岩石能够承担的容许支承压力来确定的。

## Chapter 11　习题参考答案

Section A

Ⅰ.

1. poor

2. reconnaissance;　preliminary

3. existing;　distribution;　character;　changes

4. design speed

Ⅱ.

对所获得的数据进行初步分析能够指出是否有个别特殊位置由于一个或更多的特色而不应作进一步的考虑。例如，如果发现一个重要的历史古迹和建筑位于路线可能通过的区域，则应立即确定通过那个区域的任何路线都不应该做进一步的考虑。在完成这一阶段的研究时，工程师可以选择一般的区域来穿越公路。

踏勘测量的主要任务是在路线带内确定几条可行的路线，并把它绘在地形图上。前期的踏勘工作要建立一条或几条可能路线的主要控制点和次要控制点，并且在有限宽度地带内，可能在几百英尺范围内，确定每条路线的位置。第二阶段是通过确立所有控制点和适合于这些控制点的平面线形及竖向线形，同时粗略地估计它们相对的造价，来确定可能路线的位置。摄影测量和计算机可以比在审查现场更多的可行路线。



Section B

Ⅰ.

1. borrow

2. superimposed;　subgrade;　distribute

3. flexible;　rigid

4. variable;　moisture;　repeated

Ⅱ.

柔性路面的结构由面层、基层、底基层（有时不采用）和路基组成。基层由一层（或多层）稳定性和密度很高的材料组成。它的主要作用是将车辆荷载作用于面层时所产生的应力分布或“分散”传递，使得传到路基中的应力不会使其产生过大的变形和位移。基层还必须具有能够抵抗由毛细水或冰冻作用产生的损害的性能。基层的施工材料主要取用于当地，在

一个国家的不同地区所使用的材料的种类会有很大的变化。例如，基层可由砾石和碎石构成或者是由经过沥青、水泥和石灰、粉煤灰等稳定剂处理过的粒料所构成。柔性路面突出的特点在于其结构力学特性，即以一定的深度将施加的荷载横向分布开，将压力传到路基，而无需通过如混凝土板那样的梁板作用。这样，通过与刚性水泥混凝土路面相比较，就很易于给柔性路面下定义了。

### Section C

Ⅰ.

1. flat
2. travel lanes;  medians
3. traveled;  emergency
4. raised;  flush;  Flush
5. outer;  inside

Ⅱ.

在重力和其他力（例如构造应力和地震活动作用引起的力）的影响下，组成任何边坡的物质都有一种滑移的自然倾向，同时这些力也受到这些物质本身剪切阻力的制约。当剪切阻力不能使边坡沿任一平面产生滑移的力相平衡时，边坡就会失稳。稳定许多年的天然边坡会由于一个或多个原因造成突然失稳，比如地震活动或地球震动等形式的外部干扰，边坡材料剪切强度的进一步减小，边坡中应力场的发展，以及风化等。

最早的道路实际上是史前时期由野生动物在地面上走出来的小径。由于它们提供了穿过稠密森林方便而快捷的道路，人们沿着这些迂回曲折的小道行走。一段时间以后，人们开始利用泥土填平坑洞和原木铺过软湿地点的方法来改善道路。这些做法虽然原始，但它们是道路建筑的开始。后来，行走方便的路线用岩石做得更坚固，道路被抬高到周围地面以上，它就成为“公路”。



## Chapter 12 习题参考答案

### Section A

Ⅰ.

1. enforcement;  environment;  energy;  policy;  geography
2. damaging;  improving
3. vehicles;  environment

Ⅱ.

运输管理机构通常从官方的观点来考虑，即运输的主要提供者，规划过程中最重要的角色被认为是政府部门和官员。但是，在大多数城市地区，运输机会包括多种多样的服务，很多服务是私有组织提供的。许多雇主积极参与雇员合伙用车计划；土地开发商关心开发地点的运输通道；私有组织如出租车公司，公共汽车公司，校车驾驶员能够提供实际的运输服务；商业组织（比如商会）可能影响政府部门的政策和规划过程。

在分析公路上的交通流时，有三个参数具有很重要的意义，它们分别是车速、车流密度和交通量。其中车速和车流密度（或称为交通密集程度）描述交通流经受的服务质量，交通量则用来衡量道路上交通流或交通需求的数量。因为任意两个参数的关系确定之后，三参数之间的相互关系就会相应确定，所以为了确定任意两个参数之间的关系，人们进行了大量的观测。

Section B

Ⅰ.

1. Trip generation
2. anticipated;　improved
3. capacity restrained;　multipath proportional
4. layout;　natures;　intensity

Ⅱ.

为了有效和反应良好，交通运输规划必须满足三个主要要求。首先，必须保证一个良好的经济和财政能力以支持交通运输的改善，资源被有效利用，交通资产被适当的维持。这与经济和财政的可持续发展概念相吻合。其次，它必须尽最大可能改善综合生活质量，不仅仅是贸易和服务的增长，在做出关系到交通运输改善的公共的或私人决策时，还要考虑到外部因素。这与环境和生态可持续发展相关。第三，交通运输产生的利益必须在社会的各个部门中公平分配。这与社会可持续发展相关。在所有因素中，经济和财政因素扮演了关键角色。对交通运输基础设施严格的经济评价，对其有效使用的合理定价，以及对其维护的足够财政供应都是非常重要的。从一个可运作的角度来考虑，环境可持续发展关心的是提升可居住住宅环境，减轻交通运输发展带来的不可避免的环境和生态影响。

Section C

Ⅰ.

1. lanes;　signal;　improvements;　management
2. high;　limited;　traffic jams
3. reduction;　greater;　reduction

Ⅱ.

改善公交服务的技术包括：快速巴士服务，停车场到市区的穿梭巴士服务，低密度地区内部环行线，改善线路编制以及调度的灵活性，简化收费方式，停车换乘设施，风雨棚，公交车站标志，公交公司现代化管理，改善乘客信息服务等多项措施。

公交优先的方法有时被应用到有轨电车的运行上，尤其是应用于信号优先的管理措施和中心区的专用街道。轻轨运输的车速和通行能力比重轨运输稍小。由于轻轨路线有分支或平行路线，因此它可以提供更多的便捷服务：行人更容易进入站点；站点间距变小，从而减少了人们的步行距离。因此，对于 10 英里（16 公里）长的城市出行距离，所要花费的按户到达的全部出行时间与那些全部立交的城市快速运输设施所要用的时间大致相同。线形公园的处置可以为设置在街道中央的路面电车提供更多的愉悦感，例如新奥尔良的查尔斯街和卡尔顿大街以及波士顿的比肯街沿线。

## Chapter 13　习题参考答案

Section A

Ⅰ.

1. bogged
2. scenarios
3. aggravate

4. crucial
5. fanciful

Ⅱ.

未来的高能源需求在经济方面的含义是很令人不安的。世界银行最近的一项研究表明，在 1980～1995 年间，仅仅发展中国家能耗增长 4.1%就需要年均投资约 1300 亿美元。这些投资中一半要靠外汇，其余的则要靠发展中国家内部用于能源的开支。

对于那些 GDP 增长不受限制而投资方向由建立较为初级的能源供应向开发和供应高效、节约燃料及废物利用设施方向发展的国家，人们更愿意向低能耗发展。这样，为满足社会所需的能量供应可大大减少初级能量的生产量。通过在经济各领域中使用目前所能利用的最为节能的技术和工艺，则年人均 GDP 增长速率可达到 3%左右。但这一途径需要巨大的结构上的改变以使高效节能技术向市场渗透，但这似乎很难在今后的 40 年中被大多数政府所实施。

## Section B

Ⅰ.

1. appropriate to
2. impressive
3. toxicity; abatement
4. irritation

Ⅱ.

在空气污染物的控制中，气态污染包括常温常压状态的气态物质，也包括常温常压下液态或固态物质的蒸汽。目前所知的最主要的气态污染物有一氧化碳、碳氢化合物、硫化氢、氮氧化物、臭氧和其他氧化剂及氧化硫。

由工业生产所排放的污染物反应了现代工业技术的创新。因此，工业生产过程中排放了一定量的几乎每一种可以想到的污染物。



## Section C

Ⅰ.

1. vibration; aviation
2. permanent
3. rhythm; blood vessels
4. grouchy

Ⅱ.

噪声分贝的范围和实际噪声的声压级之间的区别需要特别指出。两个相同的噪声源强度会增加两倍，噪声声压级大约增加 3 dB。对于听觉，大约增加 10 dB 才能使发出的声音让收听者听起来像是以前两倍那么响亮。

与标准或准则相比，如果噪声的声压级太高了，必须采取措施控制噪声。如果是以噪声源为目的，这些措施发挥最大作用。有四个不同的方法可以从根本上控制或减少噪声的声压级：

(1) 对暴露在噪声中的人进行保护。

(2) 通过阻断传播路径减少噪声。

(3) 增加到噪声源的距离。

(4) 在噪声源降低噪声强度。

## Chapter 14　习题参考答案

### Section A

Ⅰ.

1. boiler
2. refrigeration
3. thermoelectric
4. compressor;　condenser;　evaporator

Ⅱ.

你可以使用任何一种燃料来加热地下加热管道内循环的水。被广泛使用的燃料是石油，一些传统的锅炉采用气体或固体燃料。最佳选择是蒸汽锅炉，因为这种锅炉在地热采暖所要求的较低温度下可以获得最高的效率。

一般的做法是采用枝状管线布局，它更加容易适应有卫星城镇的大城市的规划和适合于非常分散的地区。这种布局可能由多组从热源供出和回流的分支管组成，每一对干管在小区内为相关区段提供保证。



### Section B

Ⅰ.

1. Radiant heating
2. thermal
3. insulation
4. exhilaration;　freezing

Ⅱ.

地热系统同样可以安装在冷却住宅中，地热冷却存在以下问题：

(1) 制冷能力因为供水和室内空气之间较小的温差而受到限制。

(2) 地表面温度不能低于 19℃。

(3) 室内空气的露点必须低于供水温度。

如果设计好的话，辐射循环加热和冷却设备可以在很接近室内空气设计温度的工况下运行。再配合地源热泵，这种系统能够提供非常好的能量功效。高加热供水温度和低冷却供水温度会降低能量功效。

### Section C

Ⅰ.

1. Btu;　approximately
2. inexhaustible
3. solar assisted refrigeration
4. sorption

Ⅱ.

吸附系统，是指开式循环或闭式循环。开式循环主要是除湿系统，而闭式循环是吸附或吸收系统。在除湿系统中，吸附剂用于对进来的空气除湿，虽然是空调工程的一部分,但在某

个意义上来说并不是一个制冷过程。

这种可再生能源可以在蒸汽吸收式制冷系统（VARS）和蒸汽喷射制冷系统（ERS）中应用。在初投资方面，与蒸汽吸收式制冷系统，蒸汽喷射制冷系统要更加有利。当蒸汽吸收式制冷系统在发生器低温时无法工作时，蒸汽喷射制冷系统可以实现制冷效果。

## Chapter 15　习题参考答案

### Section A

Ⅰ.

1. Humidity
2. congregate
3. heat gains
4. tropical

Ⅱ.

天气热的时候，人们喜欢在凉爽有空调的餐馆用餐，在空调房间会睡的更好。飞机、火车、船舶、公汽、汽车都是有空调设备的，会使乘客更舒适。空调系统可以洁净室内空气，减轻花粉热患者的痛苦，因为它可以清除空气中的花粉。空调还可以保护医院内病人和医护人员的健康，提高他们的舒适程度。

在公司和工厂，空调系统可以提高工人的效率，雇员在有空调的办公室或车间里工作会更加警觉，不易疲惫，较少出错，降低意外。空调可以帮助工人抵抗高温和有害粉尘、烟雾和气体。在商场，空调可以保持商品清洁，提高销售量，因为人们喜欢在舒适的环境下购物。

### Section B

Ⅰ.

1. ventilation
2. boils down to
3. dispersed

Ⅱ.

由于风和室内外空气密度差作用的结果，建筑物里产生自然换气。如不加以控制，这样的自然渗透是不规则的。如果设计出一种配置能在多变的室外条件下保持所希望的室内空气状态，这种过程才能正式地成为“通风。”

如果设计的好，维护和管理得当，这些系统能创造出可精确控制的舒适环境，但是它们非常昂贵并且能耗大，而且还会带来其他问题。

### Section C

Ⅰ.

1. residential;　commercial
2. refrigerant
3. antifreeze

Ⅱ.

在商业建筑中这几年来一直使用热泵，热泵是用来从冷的区域向热的区域传递能量。在大型的建筑中，当在建筑周围区域加热时，在内部区域通常需要制冷。

吸收式热泵也是一种很普遍的热泵，在许多位置设置这种热泵，可能效率会更高。吸收式热泵从低温热源吸收热量，比如像废热或者地表水，并把这些热量输出到较高温度区用于冬天供热。

## Chapter 16　习题参考答案

### Section A

Ⅰ.

1. dangerous;　dirty;　hard;　unreliable
2. large-scale;　high-level;　complex
3. property;　procedures;　equipment;　issues;　valuable
4. anxious
5. possibility;　severity;　hazards

Ⅱ.

在某些建筑企业，安全计划的执行落实到一个安全经理身上；其他的企业将此责任赋予给了总裁。然而，不管安全计划是如何被执行的，项目经理将成为构成整个安全计划的一部分，而且必须注意安全规程。

当然，一个公司制定安全计划需要花费金钱。一个普遍的大拇指规则是，一个有效的公司安全计划将花费直接劳动成本的 2.5% 左右。然而，事实是必须认清安全成本和公司其他花费之间的重要区别。区别是为安全花费一美元，可以为承包商节省两美元。尽管这个比率仅仅是个比喻，但是这已经充分表明，安全计划的费用所得到的补偿会远远超过那些未发生的事故省下来的钱。



### Section B

Ⅰ.

1. adjusting
2. exceed
3. appearance;　safety;　reliability;　performance
4. engineering;　architectural;　indicating
5. progress;　up-front

Ⅱ.

在项目采购方式上，使用传统的（设计—投标—建造）方式的情况已明显减少，管理方式的使用增长缓慢，设计与建造方式的使用略有增加（但波动很大）、分包已经相当普遍，因此，不论采用何种采购方式，总承包商仅充当建筑管理者的角色。

项目采购将转向以承包商为主导的方式。到 2001 年之前，设计与建造的方式将被广泛采用，其重要程度将增加两倍。管理方式将应用于大型项目，它将继续维持所占市场份额。传统方式仍很重要，对于较小型项目和重建项目来说，尤其如此。

### Section C

Ⅰ.

1. delivery
2. mandatory;　accredited.

3. policies;　procedures;　practices
4. changes;　mistakes;　omissions;　conflicts;　disputes
5. philosophy

Ⅱ.

传统的质量控制是保证工程质量技术的实际应用。贯彻质量控制技术没有固定的方法，因此在进行质量控制的公司之间不可能存在内容统一的质量。质量控制的多样性导致顾客不能确定任何一家公司的质量控制效果，也就导致公司市场效力的丧失。为了改善这一状况质量保证应运而生。

质量保证强调预防，与质量控制不同的是它主要侧重对产品制造或施工过程中的缺陷的检查。它关注的是产品或施工管理和程序方法以保证该生产系统的质量。质量保证的最终目的是为了提供给业主质量保证，这样能保证他不必检查施工过程。

## Chapter 17　习题参考答案

### Section A

Ⅰ.

1. alternatives;　methods
2. fundamental;　challenging;　execution
3. directing;　controlling;　coordinating
4. bar charts;　network analysis;　activity-on-the-node;　activity-on-the-arrow
5. powerful

Ⅱ.

承包商是施工过程三方中在计划过程中投入努力最多的一方，因为计划完善的、仔细监控的和控制的合同，在合同和公司中会产生直接的经济效益。由于计划带来的收益清晰可见，几乎没有人对计划工作的必要性表示惊讶。

在项目一开始工地现场经理需要计划或工作程序以确定资源的需求。在该项目进行的过程中现场经理也需要制订计划以协助管理资源、监控过程，估计因产品质量、错误操作、天气变化或由业主及设计方引起的变更对工程造成的影响。甚至在某些形式的合同中工地经理需要制定项目规划以便监控进度以及确定工程过程的支付额。工地经理所使用的时间单位一般是周或日。

### Section B

Ⅰ.

1. characterized
2. escalation;　contingencies;　profit
3. portfolios;　programs;　projects
4. hierarchical
5. design;　bid;　control

Ⅱ.

建筑业与其他制造业不同，成本控制考虑的对象是具有一次性特点的个体工程。因为每个新合同都会成立一个新的管理团体，工地分散在全国各地导致不能与公司其他部门及时有

效的沟通交流，大量地采用分包和临时用工的形式，以及变化的天气情况等，这自然就使实现有效的管理变得困难。

控制成本显然是绝大多数管理者的目标。应当认识到并不是只用一些简单的文字工作就能实现控制。只有将管理者的决策最终通过不同的方法具体落实才能实现控制。文字工作可以为采取什么样的成本控制提供指导，称之为成本控制系统倒不如更确切的称之为成本信息系统。

Section C

Ⅰ.

1. formalized
2. rights; obligations
3. lump sum; cost-plus-fee; unit cost
4. bid bonds; payment bonds; performance bonds
5. forfeited

Ⅱ.

通常，业主要求总承包商取得一份履约担保和付款担保，以确保能为完成工程提供资金，并能在总承包商违约时支付有关账单。同样，总承包商希望了解业主能否履行其合同中规定的义务。

同样重要的是，分包商也应充分了解业主与总承包商所签合同中的规定，因为这些规定通常以参照形式成为分包合同的一部分。这就是说，总承包商要约束其分包商履行他就分包商承担的工程部分向业主承诺的义务。分包商同意承担这些责任之前，通常坚持要享有总承包商根据其与业主所签合同应享有的各项权利与补救办法。

## Chapter 18 习题参考答案

Section A

Ⅰ.

1. conjures
2. goods; services; supply; demand
3. availability; construction; material; government; financial
4. population; demographics; employment; wage
5. changing

Ⅱ.

潜在的购买者希望在他们的投资上支付足够低的价格获得充分的回报，然而卖方希望以足够高的价格销售其资产。不管这个房地产是一个所有人拥有的住宅，一项投资财产，一项租赁业务，有限合伙公司的股份，或者是其他形式的所有权，每一笔涉及房地产所有权或者使用的交易都需要类似的投资估算。

除了购买和销售房地产的决策之外，在所有权期间投资决策会再次发生。例如，所有人必须要确定花费在财产保养与维修上的钱。所有人必须决定是否修复、现代化改造，以及扩大空间或者把资产供其他人使用。甚至，放弃房地产的决策也是一项投资决策。

## Section B

Ⅰ.

1. large; complex; diverse
2. experienced
3. prominence
4. adopted; play
5. interesting; confidential

Ⅱ.

承包商的注意力正在集中到远东地区，太平洋周边及东南亚地区的发展中国家都是十分具有吸引力的地区。特别是中国，英国的机构可通过香港而捷足先登；然而，日本、美国等的一些效力很强的公司也将在这些地区寻求获取工程。

英国的建筑在基础设施项目方面将有所扩大，维修和重建项目将成为主要特点。承包商将经常通过联合方式提供专业化的服务，合伙经营不断发展，信息技术与手机辅助设计将继续发展，各系统之间的兼容性与综合性更加引人注目。对环境问题的考虑不容忽视。全球的国际化进程将继续加快，重点更加指向远东和太平洋周边国家，如果政局稳定，还有中欧与东欧国家。

## Section C

Ⅰ.

1. injury; damage; loss
2. unfamiliar; experience; knowledge
3. completion; cost; business; commonplace
4. Probability; frequency; impact; importance; exposure
5. quantitative; qualitative

Ⅱ.

与其他许多行业相比，建筑业面临着更多的风险和不确定性。从最初的投资评价到项目建成投入使用，通常是一个复杂的过程，其中包括耗时较长的设计和建造过程。这一过程需要大量不同专业的人员参与，以及对范围广泛的一系列相互独立又相互联系的活动的协调。不但如此，这一复杂过程还受到大量外界及不可控制因素的影响。

在对工程中存在的内在风险进行探讨时，令人惊讶的是，仅仅在过去十年，风险识别、风险分析及风险防范等管理技术才开始在建筑业中应用。大多数人都同意风险在决策中扮演了一个非常重要的角色，风险可能造成的损失会影响投资者所追求的收益。从本质上说，风险来源于不确定性，而不确定性则来源于信息的匮乏。